Uttar Pradesh
Rajarshi Tandon Open University

MBA-4.4
Technology Management

Block

1

TECHNOLOGY : ISSUES AND IMPLICATIONS

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S 94 TECHNOLOGY MANAGEMENT

ıe modern age technology is perhaps the most important resource to any nation. traditional concept about wealth of a nation—that it consists of gold, silver, ıonds, rubies and pearls, and natural resources including precious minerals such ;troleum, cobalt, platinum, chromium, manganese and nickel—is undergoing ge. It is increasingly realised these days that a rich endowment of natural and ral resources and good crop lands, critical as they are for any nation's economic lopment, do not by themselves make factories run. That is why most economics accept the notion that total output of goods and services (GNP) is the real ure of national wealth.

ιin, USA and other countries of the West became rich because of technological vation in several fields, including mineral extraction, manufacturing, power and port. In these countries the extraordinary profits generated from technological vation in such industries as telephones, electrical equipment, autos, and iicals financed rapid growth and job creation. Much of the increase in per capita ut (as much as upto 90 per cent), as some studies have indicated, is attributed to ınical progress". Capital and labour inputs contributed much less. Capital tment *per se* is not the dominant factor in increasing productivity. It therefore ws that invention, innovation, investment in risky ventures, adoption of new ıologies and new products, institutional learning and so forth are the major esses in wealth creation. The United States became the richest country in the d a century ago, primarily on the strength of its superior ability to innovate and e new business enterprises.

:hnology is crucial to the economic development of a country then the ıgement of such an important resource, both at the national and enterprise s, cannot but be vital. The technology and its development cannot be left to the s of chance. As an important resource it has to be properly planned, cultivated developed. Forces within the firm for technological growth have to be harnessed, nised and encouraged. Problems needing technological solutions have to be ified, alternative solutions have to be generated, analysed and evaluated. All this for an imaginative and effective management of technology for sustained th of the enterprise and for greater competitiveness. In this course on **nology Management** our focus, would be mainly on the management of ıology at the enterprise level, though management of technology at the national would also be considered.

day's environment technology management is an important area of study for a ıess manager, especially for the top and middle level managers who have ınsibilities of general or overall nature. In fact, some management experts are of pinion that in the present environment there are two core subjects to which management student must be exposed: one is Technology Management and ther is International Business. For rapid economic development, India needs to e greater awareness about the role of technology and internationalisation of ıess. It would be no exaggeration to say that we need to develop a culture of ıology and a culture of outward looking.

ıown in Figure—TM, Technology Management embraces some key ions/elements, such as technology forecasting, technology generation and opment, technology transfer, absorption, evaluation and assessment, and ion.

:ourse on Technology Management is divided into five blocks. The first Block ıology Issues and Implications essentially is introductory in charactor and deals the concepts and definitions and some essential aspects of and issues in ology. The second and the third Blocks in fact comprise the core of the ology management. The second block titled "Development and Acquisition" with technology forecasting, technology generation and development, and ology transfer. Block 3 "Absorption and Diffusion" deals with some other tial elements of technology management, such as technology absorption, ology assessment and evaluation and technology diffusion.

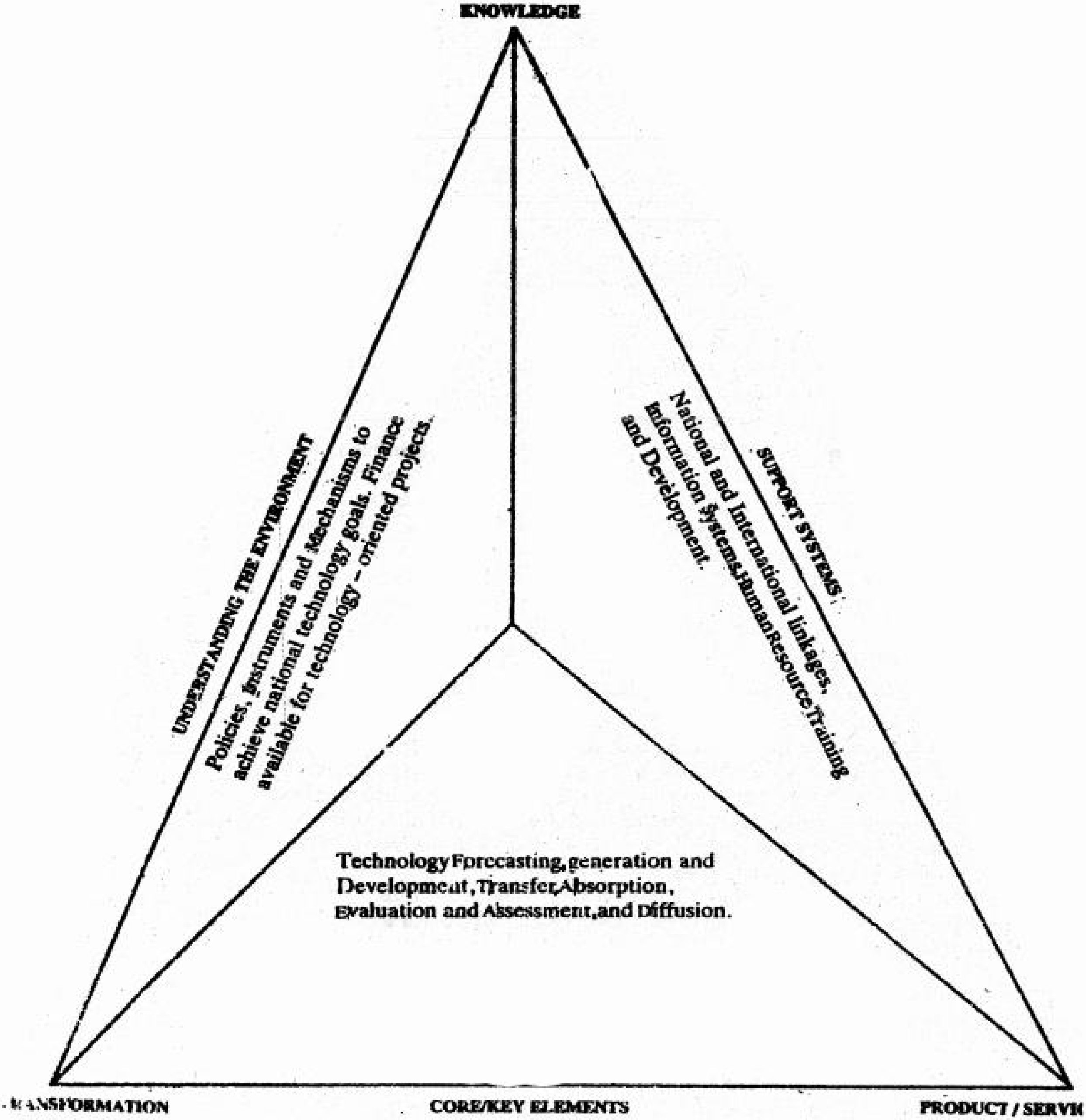

Figure TM: Scope of Technology Management

The manager after all has to work within a certain (technological) environment. H must have a fair understanding of the opportunities and constraints of the environment at the macro level under which he operates. The fourth Block theref looks at the Government policies on technology and the various instruments available to achieve national technology goals. It also provides the manager som exposure to the national and international linkages in the area of technology.

Block 5 presents a discussion on some support mechanisms available to a mana It begins with a discussion on the financial support available for technology based / oriented enterprises. The role of information systems and sources of information for present and future technologies are described. The Block (and th Course too) concludes with a capsule unit that attempts to integrate the knowled learned in the previous units. It closely looks at the various elements of / issues i technology management at the enterprise level, e.g., technology strategy, technol adaptation and upgradation, identification of technology gaps, evaluation of technology options, monitoring systems, etc.

,OCK 1 TECHNOLOGY : ISSUES AND IMPLICATIONS

‹ I Issues and Implications introduces you to the various facets of technology ts management, aspects, issues in technology and implications of technological ge. It has three units.

I Issues and applications gives a conceptual understanding of technology. : terms in relation to technology and its management are defined. The role and rtance of technology management is underscored. Since technology management e component of the total management system, it must be interwoven with other /dimensions of a business enterprise. The best way to bring about this kind of ration is to prepare an all-encompassing business or corporate plan. Finally, the examines the situation with regard to technology management in India.

2 **Aspects and Issues** deals with some aspects of and issues in technology, both e national and enterprise levels, but more so at the former level than the latter. need for technological change is explained. The meaning and significance of nology Life Chain and Technological Transformation are also explained. The ept of "appropriate technology" has been an exciting subject for discussion at ius national and international forums. What is appropriate technology is ever not easy to define or precisely lay down. It depends on the surrounding mstances. What are these surrounding circumstances and how we select a iology which would be appropriate in a certain case is discussed in sufficient l. The role of technology policy and instruments to achieve national level goals amined. Technology development options and strategies available to an iisation are then taken up. The need for a closer link between technology issues ocio-economic planning process is emphasised. The unit concludes with a ssion of the considerations that would govern the development and management chnology.

3 **Implications of Technological Change** attempts to examine the impact of iological change on the production function. The nature of technological change cussed. The impact of the revolution that is taking place in information iology on products, services, processes, and on organisations is discussed. lly, the macro effects of technological change in relation to method of uction, skills required and competitive advantage are explored.

UNIT 1 BASIC CONCEPTS

Objectives

After studying this unit, you will be able to :

- acquaint yourself with some definitions/nomenclatures concerning Technology and Technology Management;
- appreciate the role and importance of Technology Management at corporate level;
- understand various elements/ constituents of Technology Management;

Structure

1.1 INTRODUCTION

The word "Technology" comes from two Greek words : techne (the skill or craft needed to make something) and. loges (discussion or knowledge of something). So Technology means the knowledge of how something is made. An economist or a planner considers technology as a knowledge used in production, commercialisation and distribution of goods and services. Technology is embodied in various forms, such as, machinery, equipment, documents, processes and skills (Figure 1.1) and as such it conveys different meanings to different specialists under different contexts. Figure 1.1

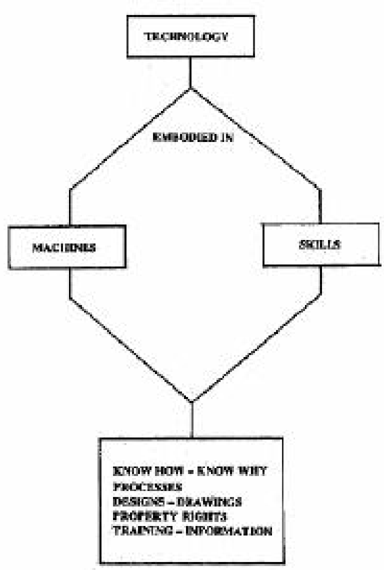

Figure 1.1: Technology Concept

Technology is man-made; it is a means to enhance the physical and mental capability of human beings, it is also an instrument to transform natural resources into useful goods; a tool for conditioning the environment; it is a resource for creating more wealth; a factor affecting development. Technology is also a commodity, which is bought and sold.

Innumerable technological developments have taken place in society during the last two centuries and it is difficult, if not impossible, to enumerate all of them. However, some significant technological developments in selected areas are presented in Table 1.1.

Table 1.1 Some Significant Technological Developments During the Last Two Centuries in Selected Areas.

Years	Food & Agricultrue	Transport & Communication	Health & General
1775—1825	Food Pasteurization and Sterilization Chemical Fertilizer for Improved Agriculture	Watt's Steam Engine Fulton's Steam Boat Stephenson's Steam Locomotive	Cellular Pathology Synthesis of Vitamins And Enzymes Whitney's Cotton Gin
1825—1875	Food Preservation and Fermentation Farm Implements for Increased Production	Faraday's Dynamo Morse's Telegraph Electric Locomotive Ships and Pipe lines	Microscope Electric Light Sewing Machine
1875—1925	Food Canning and Freezing Animal Breeding and Agricultural Experiments	Automobile, Aeroplane and Submarine Printing, Telegraph and Telephones Larger Ships	X-Ray Vaccination and Immunization Wireless and Radio Textiles
1925—1950	Dehydration Irradiation and Vacuum Packaging of Food Hi-Breed Plants and Intensive Farm Mechanization	Steam and Gas Turbine High Speed and High Payload Ships Passenger Aircrafts Supersonic Jets	Antibiotics and Contraceptives Atomic Reactors Digital Computers Transistors
1950—1975	Semi-Processed and Pre-blended Food Integrated Farming and Aquaculture	High Speed and High Pay-load Aircrafts Nuclear Powered Ships Micro-wave Link and Communication Satellite	Transplantation of Organs Integrated Circuits Synthetic Materials Vending Machines
1975—	Non-conventional Food Items (single cell protein technology)	Supersonic Passenger Aircrafts Fibre-optical Tele-photo communication	Advances in Bio-engineering Artificial Organs
	Computerization	Computerization	Computerization

Source : Sharif, Nawaz, 1983. Management of Technology Transfer and Development, APCTT, Bangalore, p. 21

Technology is generally a combination of hardware and software with relative proportions varying from one extreme to the other. Hardware is any physical product, component or means, while software is the know-how, technique or procedure. Hardware technology again can be of two types, namely: the end-use product type such as automobiles, computers, televisions, and the production tool type such as instruments, equipment and machinery. Software technology can also be considered as being of two types, namely: the "know-how" type technology such as processes, techniques, methods; and the, "know-why" type technology such as knowledge, skills and experience.

Thus, technology is neither merely a product nor a process. It is now recognised as a means for the survival, order and progress of the human world. Technology does not exist in isolation. It exists in human surroundings. Every technology when applied causes some alterations in its human surroundings. Most of these alterations have been beneficial to the mankind. However, there have been some harmful effects as well. Technology is only a means for development and not an end in itself. It is, therefore, essential that while determining strategies for technological advancements, one must adopt an optimum approach of maximising the positive or beneficial effects while at the same time minimising the negative effects of technology, especially relating to atomic energy, deforestation and ecological balance, total automation, artificial intelligence, etc.

According to Nawaz Sharif,' "Technology" is-
a "game" for the rich,
a "dream" for the poor, and
a "key" for the wise.

Technology has been viewed differently by different people. Some view technology as a source of wealth, well-being, and above all, as an instrument of power to dominate nature and societies. Others view technology as something that has enslaved human beings and destroyed jobs, environment and social values. While there is a considerable concerns that the use and abuse of technology is leading our societies towards disaster, there is also considerable agreement that further development of human society is possible only through the application of technology. If we can master its use, technology can be the "key" to a prosperous society for all human beings-including the poorest of the poor. Most of the poor countries, in fact, are rich in natural resources. However, they have their basic problems: (i) they have a relatively large population base, which is increasing very rapidly; (ii) their technological base is very small and ineffective; and (iii) their natural resource base is being depleted due to inefficient use and indiscriminate export. To acquire and master the use of technology for development, it is essential to understand the basic concepts' of technology and the process of effective technology management.

The fact that we now live in a technological world can be seen very easily by observing the ways and means of satisfying "human needs" in various societies. There are many ways of classifying human needs. Table 1.2 indicates the implications of technological applications (positive effects and negative effects) with respect to various human need factors.

Table 1.2 : Some Implications of Technological World

Table 1.2 : Some Implications of Technological World

Various Human	Direct and Indirect Effects of Technology	
Need Factors	Positive Effects	Negative Effects
1. Air	Control of temperature, humidity, impurities and quantity	Pollution; destruction of natural cycles, and equilibrium
2. Water	Increasing supply source (ground, sea); control of supply, temperature and impurity	Pollution; destruction of marine life; sinking of cities; frequent flooding
3. Food	Improved agricultural productivity; control of food quality, variety and supply	Chemical contaminations and diseases; destruction of wildlife, forests, and fishing grounds
4. Shelter	Improved living quarters and materials of construction; better utility services and land uses	Artificial surroundings and anti-social living; destruction of the beauty of nature
5. Warfare	Development of civilian technologies as by-products of war technologies (space, nuclear, remote-controlled)	Accumulation of means of warfare and the menace of large-scale destruction of life; risk of bio-weapons and nuclear war
6. Clothing	Efficient production of high quality clothing and apparel	Exploitation of non-renewable resources and consumer appeal
7. Health	Reduction in mortality; increase in life expectancy; controlled birth; better medical care	Population explosion; break in family structure; drug abuses; side-effects of medication
8. Communication	Increased contact; reduced need for playsical movement; improved audio-video transmission	Culture shock; coordination of sabotage by disruptive forces; raising false aspirations
9. Transportation	Improved mobility of people and goods through air, water and land	Pollution, noise, congestion, accidents and deaths
10. Education	Better means for storing and dissemination of knowledge	Brain-washing through massmedia; destructive education
11. Work	Much specialization and automation possible; increased women employment	Tension between blue-collar and white-collar workers; increased inequality; strikes
12. Institution	Creation of systematized, efficient and highly productive large complex organizations; exploitation of natural resources; enhancing human power	Depersonalization of human beings in the quest for efficiency and productivity; depletion of energy and other natural resources; innumerable industrial wastes
13. Information	Tremendous improvement in processing, storing and disseminating voluminous information	Privacy and security problems; crime and misuse of information power
14. Energy	Development of alternative sources of energy—fossil, solar and nuclear	Threat of nuclear plant accidents; depletion of energy resources
15. Freedom	Freedom from one set of constraints (physical stresses)	Creation of new set of constraints (Psychological stresses)

(**Source** : Sharif Nawaz, Management of Technology Transfer and Development, APCTT, Bangalore, 1983)

1.2 DEFINITIONS

Technology seems to be the most **widely used word today** in industrial world and several words/ nomenclatures connected with technology are in vogue. These include R&D, invention, innovation, technology development, technology strategies, technology absorption and adaptation, technology transfer, technology forecast,. technology assessment, technology planning, technology information, industrial property systems, code of conduct, and technology management. It is difficult to find a unique definition for technology for it has been defined in many ways. One definition identifies **technology** as an application of knowledge that leads to production and marketing of goods and services. According to Betz, Technology develops business by providing technical knowledge for the goods and services that a firm produces.[2] **Technological innovation** implies new technology, creating new products and services-hence new business **opportunities.** In this lies the basic importance of innovation. which is fundamental to economic development i.e. the creation of business opportunities. Managing technology means using new technology to create competitive advantages which is quite a difficult job, partly **due** to differing cultures in a company. Technology is often thought to be solely the domain of the scientific and engineering personnel of an organisation. Yet, successful business use of technology requires strategic decisions about technology by personnel in other functional areas, such as production, marketing, sales, finance, and so on. Thus, the two cultures-technical and functional-need to be bridged, and management should integrate technology strategy with business strategy. This is **the essence of technology management.**

Innovation and Invention : Invention is an idea for a novel product or process. Innovation is the introduction of new products, processes or services into the market place. Technological innovation is a sub-set of innovation i.e. the introduction of new products, processes or services based on new technologies. The technological innovation begins with invention. The first step is the idea of the invention and the research to reduce the idea to practice. This often results in a functional proto-type, which can be) used for filing a patent. The next step is the research and development of the proto-type into a commercially designed product. Finally, the product is produced and sold.

The distinction between invention and innovation is an important one, for the transformation from ideas into a successful product is actually difficult. This transformation is the heart of the complex process of innovation. The hard fact is that only a few inventions are successfully innovated, with fewer inventions developed into new products, and still fewer new products succeed commercially. The problem of managing technology thus can be divided into two parts : (i) encouraging invention, and (ii) managing successful innovation. Encouraging invention falls in the area of corporate research and managing successful innovation falls in the area of managing technology.

Technology Management: Many factors make up the technology development framework and there are several ways of condensing these into a manageable number of groupings. Figure 1.2 shows these factors grouped around six broad dimensions:

i. Objectives
ii. Decision criteria
iii. Time
iv. Constraints
v. Activities
vi. Mechanisms

Obviously, these dimensions are interlinked and a proper management of technology requires a systematic consideration of all of them.[3] Figure 1.2 shows the dimensions of Technology Management.

According to Solomon, Technology Management is the capacity of a firm, a group or society to master management of the factors that condition technical change so as to improve its economic, social and cultural environment and wealth.[4] That technology management is important becomes obvious if one considers both what the economists call the "input" and the "output" aspects of technical change, namely, sources of modern technology on one side and its pervasive impact on society on the other. These facts are obvious for all countries. However, technology management is more important for those countries which do not participate directly in the "input" aspects, or do so less intensively than the industrialized countries, and are therefore necessarily less well-prepared to adjust to and master the "output" aspects. This is the case today in most developing countries. According to Stephen Millett,[5] the following four general factors are considered important to successful R&D management :

i) a responsiveness to the needs of clients and customers;
ii) regular top-down and bottom-up communication;

iii) an awareness that technologies alone are not products; and

iv) recognition that non-technological factors have profound impact on R&D.

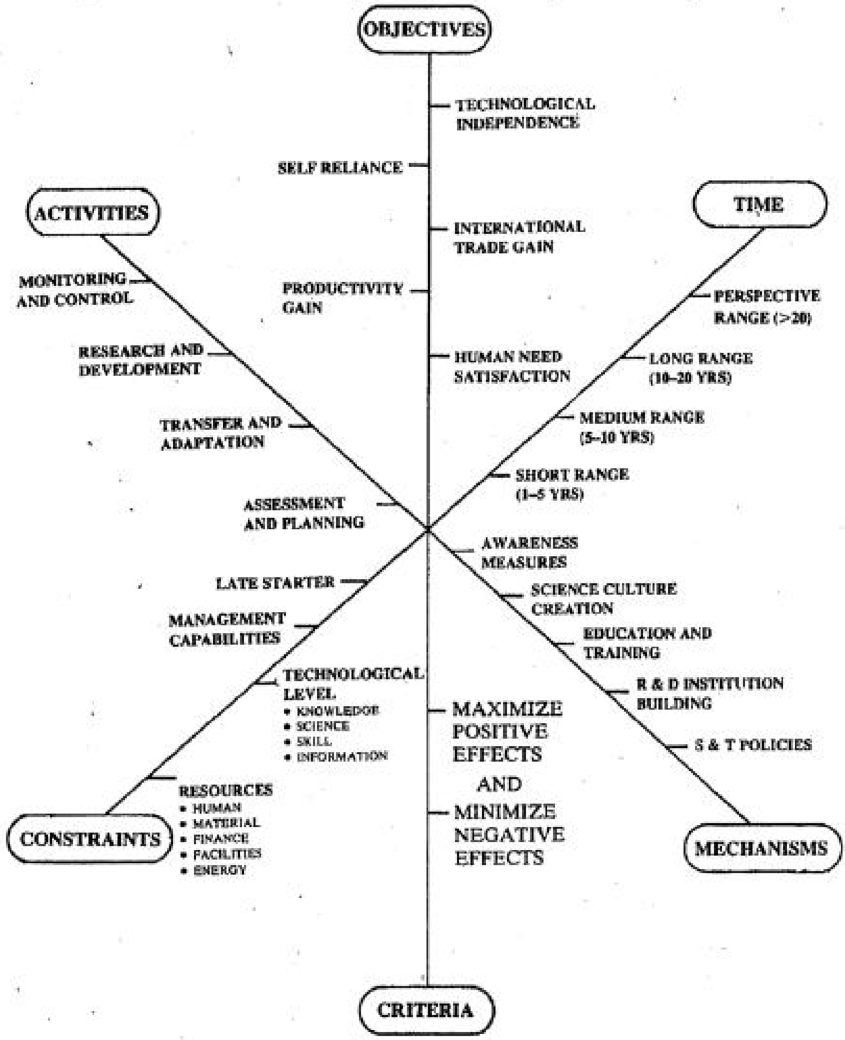

Figure 1.2 : Dimensions of Technology Management

Activity 1

Arrange a meeting with the head or senior functionary of the Engineering and Technology' Division of your company or any other relevant organisation with which you are familiar. Discuss with him the following and note down the main points that emerge in the course of discussion :

a) What is meant by technology? In other words what is the scope or what are the constituents of technology?

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b) Has the organisation done anything during its existence which can be called innovation or innovative activity?

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1.3 ROLE AND IMPORTANCE OF TECHNOLOGY MANAGEMENT

Technology and management of technology are critical for an enterprise for its successful operation on long-term basis. Technology management is, however, a part of the total management system. There are three basic considerations for starting any new firm based on technological innovation.

a) The idea for a technological innovation;
b) A potential market;
c) Team work in both technological and business expertise.

The above points underline the need for interweaving the technology framework with other areas of business in an enterprise. The idea of a technological innovation should be based or linked with the potential market and the technology team should closely interact with the rest of the divisions of the enterprise leading to successful logical conclusions in terms of products/ processes to be developed as per the objectives set in the beginning. This strategy is best reflected in the form of a "Business Plan" of an enterprise which needs to be prepared and approved before starting the new business.

The Business Plan : The business plan is a strategic summary of a new venture. Its purposes are:

i) to ensure, by clear focus in strategy, that important points necessary to the success of any business venture, have been considered; and
ii) to persuade financial investors to invest in the new venture. A new venture business plan could include the following:
   a) Current business status
      – Business objectives
      – Management and organisation
   b) Products or Services
      – Product description
      – Technological background
      – Competition
   c) Benefits to customers
      – Market Competition
      – Marketing strategy
   d) Capitalisation
      – Capital requirements
      – Financial forecasts
      – Benefits to investors

It is thus clear from the above that technology and technology management are only a part of the total business activity or business plan of an enterprise.

Technology and Competition : Although technological competitiveness is necessary for corporate survival, it alone is not sufficient. Of course, a corporation with inferior technology cannot compete at the same price level with a corporation superior in technology. The reason why superior technology alone is not sufficient is that business is a system, and there are many other systems (or sub-systems) that determine business success. Therefore, if technology is to give a competitive edge, management must manage it as apart of the business system. Technological innovation can be integrated with production, marketing, finance and personnel into a balanced business system. Managing technology essentially involves four central concepts:

a) New ventures
b) Innovation
c) Research

d) Research infrastructure

New Ventures : Although new ventures centred around technology are an important class of businesses, new hi-tech ventures are difficult because they involve two major risks: developing new products and creating new markets. Ideas central to new ventures are concerned with entrepreneural management, overall business plan, and the dynamics of organisational growth.

Innovation : It denotes the whole span of activity from creating new technological knowledge to implementing it in new businesses. Ideas central to innovation include concepts such as types of innovation, processes of innovation, the-technology S-curve, technology life cycle, economic life cycles, sources of innovation, business opportunities in a technological system, marketing and new technology, corporate diversification through new ventures, and technology in manufacturing strategies.

Research : Technological change is new knowledge about what things to produce and how to produce them; and in the corporation, new knowledge often comes from corporate research. The corporate laboratory is charged with the responsibility of looking after the present and future productivity of the corporation. Managing and integrating corporate research with other management functions and strategies is essential to technology management. Research management includes organisation of research, project management research personnel, and corporate research strategy.

Research infrastructure ! The technologies of a corporation do not exist in a vacuum but are part of a larger technological context, first of the. industry, then of the nation, and then of the world. This larger context is a research and development infrastructure, and it has an important influence on the competitive conditions in a country. With the expansion and increase of intensity of international competition, the R&D infrastructure of a nation plays a critical role in economic competition.

Managing technology is taking risks in novel products and developing new markets. In the world of rapid technological progress and changing competitive environments and market needs, firms must pay increasing attention, to developing new innovative products for domestic and world markets, and therefore an efficient technology management system is important for them.

Let us first clarify the distinction between innovation, and invention since invention is only the beginning of innovation. The steps required to transform invention into innovation can be illustrated in the famous Xerox story.

In 1935, Chester Carlson was working in the patent office of Mallory Company. His technical background included work as a carbon chemist, printer, and then as a patent lawyer, He became concerned about the errors in copying patents for public dissemination and the costs involved in copying. Using his chemistry and printing background, lie began experimenting with new ways to create a copying process. His basic idea was (a) to project the image of a typed paper onto a blank 'sheet of paper coated with dry ink, (b) to hold the ink temporarily at spaces of typed letters by static electrical charges induced by the light, and (c) finally, to melt the ink into the paper by baking the paper. This would produce a quick, dry reproduction of a typed page; and the process came to be called Xerography.

Carlson succeeded in obtaining a crude image, thereby reducing his idea to practice. He filed for a patent. Yet like all new inventions, it was still not commercially efficient, cost-effective, or easily usable. It required development. Development of a new technology usually costs a great deal of money, takes time, and requires skilled resources. All inventors face similar problems-first conceiving the invention, reducing it to practice, obtaining a patent, then obtaining support for development and commercialisation.

Carlson went from company to company seeking support. He was turned down, again and again. By 1942, he had obtained the valuable patent on the basic process. Then a venturesome group at Battelle Memorial Institute agreed to work on the development in return for a share in potential royalties. Battelle was a non-profit research' and development organisation, with a range of advanced technical research capabilities.

Finally, the innovative pieces for Carlson began to fall in place---invention, patents, development and commercialisation. In 1945, while Battelle began development of the Xerography process, a small company named Haloid learned of Carlson' patents. Joseph Wilson, the president, was a risk-taker and was looking for new products. Wilson produced the first copiers, using Carlson's patents and Battelle's developments.

The rest of the story became business history. That company became Xerox, creating a new industry in office copying products. Xerox grew tremendously, keeping a technological and marketing dominance over the industry for almost three decades.

The interesting questions to ask are : How many companies missed out on the xerography patents? Why did it take an R&D outfit like Battelle to see the technical potential in Carlson's invention? What leadership qualities do innovative, risk-taking managers like Joseph Wilson possess?

Effective technology management in various countries have led to several technological advancements in the past. In table 1.1 we had listed for you some significant technological advancements during the past two centuries in selected areas. Recent Gulf War (1991) is another burning example of technological

Table 1.3 : Speed of Introducing Technological Development into Social Use

Specific Technology	Invention	Innovation	Speed of Change
Aspirin	1853	1899	46
Incandescent Lamp	1854	1880	26
Telephone	1860	1887	27
Photography	1871	1888	17
Synthetic Rubber	1882	1932	50
Ballpoint Pen	1888	1938	50
Fluorescent Lamp	1896	1938	42
AM Radio	1900	1920	20
FM Radio	1902	1936	34
Aeroplane	I903	1920	17
Vacuum Tube	1904	1915	II
Helicopter	1907	1938	31
Black & White Television	1907	1936	29
Colour Photography	1912	1935	23
Colour Television	1925	1953	28
Nylon	1927	1938	Ii
Penicillin	1929	1942	13
Jet Aircraft	1930	1942	12
Polaroid Photo	1937	1948	bI
Xerography	1937	1950	13
Electronic Computer	1945	1951	6
Transistor	I947	1951	4

Source :Sharif, Nawaz, 1983, Management of Technology Transfer and Development, APCTT, Bangalore, p. 28.

advancements in which defence systems using latest developments in materials, electronics and computers, etc. were used by USA against Iraq. There is evidence to show that there has been acceleration in technological change all over the world during the last one hundred years. Table 1.3 gives some evidence to indicate that there is a decreasing trend in the speed of introducing technological developments into social use. The time of substitution has also decreased over the years. This has stepped up the pace of invention, innovation and substitution/diffusion. This means acceleration in the whole process of technological change. The new machines and techniques are not merely products, but sources of fresh creative ideas.

Activity 2

Examine with reference to your organisation the importance given to the technology component in the overall (corporate) plan. Take up the long term corporate plan and look for the place accorded to and figures incorporated therein related to technology component.

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1.4 TECHNOLOGY MANAGEMENT IN INDIA

The development of science and technology (S&T) has been receiving continuing attention of the government at the highest level in India. However, this development has been based more on science than technology. On the industrial scene, the Indian industry accounting for almost one-third of total production, has been generally operating under controlled and regulated economy, in other words, assured markets. The industry did not generally realise the real need for international competitiveness in most of the sectors. It, therefore, did not give adequate attention and also did not make adequate investments in technology. The technology management at enterprise level in India has therefore been practically lacking except in a few cases. There have, however, been several instances where Indian companies have been able to develop and produce products for internationally competitive markets. Punjab Tractors, Tata Automobiles, Amul Food, certain drugs and chemicals produced by some firms, are some examples where Indian companies have excelled. Similarly, some of the R&D institutions have developed and commercialised technologies in areas such as drugs and pharmaceuticals, chemicals, food technology, computer: software, etc.

The Indian industrial production has been substantially based on imported technologies, accompanied by import substitution efforts through indigenous sources. It is recognised that a large number of industrial products today are based on obsolete technologies which are not cost-effective and consume lot of energy. Further, they are not friendly to the environment, and their quality is not of desired level. The technology management at enterprise level has therefore been mostly limited to choice and acquisition of technologies from abroad and adapting the same to Indian requirements. This generally involves only incremental developmental efforts rather than innovations. Market forces play a decisive role in technology strategies at enterprise level. Since Indian industry has largely enjoyed monopolistic markets, their interactions with S&T based institutions, R&D laboratories, and academic institutions have been rather limited, and their R&D expenditures have also been much less than the desired levels (when compared to investments in R&D by industry in developed or industrially advanced countries). In fact, there appears to be a technology paradox in India as far as S&T is concerned. On the one hand, we have developed capabilities of high order in hi-tech areas such as space, atomic energy, defence and computer software; on the other hand, our manufacturing capabilities are limited to, products ranging from needles or paper pins to electronic products, the quality levels are low and prices are not competitive. We have imported technologies for almost everything that we use.

With the announcement of the New Industrial Policy and other fiscal measures by the Government in July 1991, the emphasis now is more on international quality, efficiency and exports. Foreign investments and technologies are being encouraged.

These policies have appreciably changed the operating environment for the Indian industry and would now call for well laid-down technology policy at enterprise level. It is expected that companies will now pay more attention to technology management in order to remain competitive. Small scale sector contributes substantially to the total industrial production and exports of the country, but often does not have adequate appreciation for technology issues and investments in R&D. The rate of sickness is also higher in this sector. The, new policy envisages a variety of measures to-support this sector, including the technology related support. It must be stressed that technology management is also important for small enterprises

Activity 3

Request your counselor to initiate a discussion *on the state of* technology management in the companies to which the students belong. Let the students assembled in the class exchange views with each other in which you actively participate. List down the main points that emerge from the discussion.

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1.5 SUMMARY

Technology underpins business, providing technical knowledge for the goods -and services that a firm produces. Managing technology means to use new technology to create competitive advantages and integrate the technology strategy with the business strategy at the corporate level, Technology management is a part of the total management system and it is only one of the important elements in the total business plan of an enterprise or a new venture. Managing technology essentially involves new ventures, innovation, research and research infrastructure. Enormous efforts and resources are required to translate invention into innovation, innovation into technology, and technology into business.

The Indian industry on the whole has operated in *a* protective environment with generally assured markets, and hence has not paid adequate attention to make the necessary investments in R&D and technology. The technology policies and technology management structures have generally not been adequately evolved at enterprise level. The industrial production is substantially based on imported technologies, adapted to local requirements, with marginal developmental efforts. There have however been instances of successful technologies developed indigenously and commercialised for domestic as well as export markets. The New Industrial Policy and other policies as well as fiscal measures of the Government of India announced in July 1991 would call for not only a systematic approach but also much larger resources and efforts for viable and responsive technology management and support facilities at enterprise levels, to meet the requirements of international competitiveness. Continued dependence on foreign technologies and technological inputs, particularly the turnkey approach for setting up a project, would need to be discouraged. An effective technology management policy and infrastructure is also necessary for sustainable exports of products, projects and services.

1.6 KEY WORDS

Business Plan : A strategic summary of a new venture.

Innovation : Denotes the whole span of activity from creating new technological knowledge to implementing it in new business.

Invention : An idea for a novel product or process.

R&D : A range of activities from invention and innovation to product/process development, upgradation, modification, absorption of acquired technology, within the framework of technology management.

Technology : Application of knowledge that leads to production and marketing of goods and services.

Technology Management : Capacity of a firm, a group or society to master management of the factors that condition technical change, so as to improve its economic, social and cultural environment and wealth.

1.7 SELF-ASSESSMENT QUESTIONS

1) Define Technology and Technology Management.
2) Explain and discuss the role of technology in the overall business strategies of a firm. How does technology affect the business plan of a company? Give examples?
3) In your opinion what has been the role of technology at enterprise level in India? What are the factors that may affect the management decisions concerning technology?
4) How do you envisage the role of technology and technology management in the new industrial environment in India'?
5) Differentiate between invention and innovation. Give one example for each. What are the dimensions of technology management? Explain.
6) What are the basic considerations for starting a new firm based on technological innovation? Explain. What is the role of technology in the business plan of a new firm? Discuss.
7) Do you agree that technology developments in India have not been very encouraging while achievements in science have been remarkable? If so, list the reasons. Suggest some ways to improve the situation.

1.8 FURTHER READINGS

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UNIT 2 ASPECTS AND ISSUES

Objectives

After studying this unit, you will be able to :

- understand the need and importance of Technological Change, Technology Life Cycles and Technological Transformation;
- know what is appropriate technology and the criterion for its selection;
- understand the need and role of technology policies and policy instruments;
- analyse technology development options and strategies available to an organisation;
- appreciate the importance of linkage between technology issues and socio-economic planning process; and
- know about some of the considerations that govern the technology development and management.

Structure

2.1 INTRODUCTION

In the first unit we discussed the concepts and definitions related to Technology and Technology Management at national and enterprise levels. In this unit we will discuss some of the issues and aspects concerned with technology. These aspects include Technological Change, Technology Life Chain, Diffusion and Growth of Technology, Technological Transformation and Technology Alternatives, Appropriate Technology, Technology Policy and Policy Instruments, Planning, Development Options and Strategies, etc. There are many more issues, some of which have been discussed in other units at relevant places. As mentioned earlier in the first unit, Technology and Technology Management are complex subjects and have several dimensions and implications. While it is difficult to cover all of these dimensions or implications, we have attempted to cover some basic issues which should provide a fairly good understanding of the subject and enable an executive to deal with matters concerned with technology management more effectively.

2.2 TECHNOLOGICAL CHANGE

Technological growth is the result of new inventions and innovations. Every invention is something new and in most cases it is a combination of already existing technological elements. An invention becomes innovation when applied for the first time. An innovation which has little disruptive impact on behaviour pattern is called a continuous innovation (e.g. fluoride tooth paste). In such cases alteration of an existing product rather than creation of a new product is involved. There are also dynamically continuous innovations which do not involve new consumption patterns but involve the creation of a new product or the alteration of the existing one (e.g. electrical tooth brush). Further, there are discontinuous innovations, which involve the establishment of new behaviour patterns and the creation of previously unknown products such as automobiles, televisions, computers etc.

The process of technological change is clearly linked to innovation. Technological change occurs through substitution and diffusion. The simplest form of technological substitution occurs when a new technology captures over a period of time a substantial share of the market from an existing older technology. The new technology is better and economically more viable. Thus after it has gained small market share, it is likely to become more competitive with time. Therefore, once a substitution has begun, it is highly profitable to eventually take over the available market. This is a simple one-to-one technological substitution process. A good example is the introduction of colour television in place of black and white television. Diffusion has been discussed elsewhere in this unit as well as in Unit 9.

There is a broad spectrum of factors, which can have an impact on the process of substitution and diffusion. These can be broadly classified into (a) factors affecting the demand for a technology; and (b) factors affecting the supply of a technology. We shall discuss implications of technological change in greater depth in the next unit.

2.3 TECHNOLOGY LIFE CYCLE

The life span of various technologies can be conveniently identified as consisting of four distinct stages, all of which taken together form the `Technology Life Cycle'. The stages of technology life cycle are *innovation, syndication, diffusion,* and *substitution.*

Innovation stage: This stage represents the birth of a new product, material or process resulting from R&D activities. In R&D laboratories, new ideas are generated by `need pull' and 'knowledge push' factors. Depending upon the resource allocation and also the change element, the time taken in the innovation stage as well as in the subsequent stages varies widely. You will recall we had discussed the terms "innovation" and "invention" in the previous Unit.

Syndication stage: This stage represents the demonstration (pilot production) and commercialization of a new technology (product, material or process) with potential for immediate utilisation. Many innovations are shelved in R&D laboratories. Only a very small percentage of these are commercialized. Commercialization of research outcomes depends on technical as well as non-technical (mostly economic) factors.

Diffusion stage: This represents the market penetration of a new technology through acceptance of the innovation by potential users of the technology. But supply and demand side factors jointly influence the rate of diffusion.

Substitution stage: This last stage represents the decline in the use and eventual extension of a technology due to replacement by another technology. Many technical and non-technical factors influence the rate of substitution. The time taken in the substitution stage depends on the market dynamics.

2.4 DIFFUSION AND GROWTH OF TECHNOLOGIES

There is another way of looking at the technology life from the perspective of growth and diffusion.

Every technology eventually reaches a decline phase owing to the development of better technologies (in terms of performance and/or cost). In other words technological change occurs through 'substitution'. The process of technological advancement through substitution is shown schematically in Fig. 2.1. Most technologies follow an S-shaped growth pattern. However, it has also been observed that, although Particular technology eventually reaches a stage where it has limited use, new technologies are developed to achieve further growth with respect to any particular `figure of merit' (i.e. index of particular requirement). For example, if one takes the speed of passenger travel as a `figure of merit', then Technology T1 is a propeller aircraft, T2 is the turbo prop aircraft and T3 is the jet aircraft. Each of these, technologies normally shows an S-shaped improvement over time. Moreover, the overall growth of these successive technologies (representing a system of high order, characterised by a succession of discontinuous innovations) also exhibits an S-shaped growth pattern.

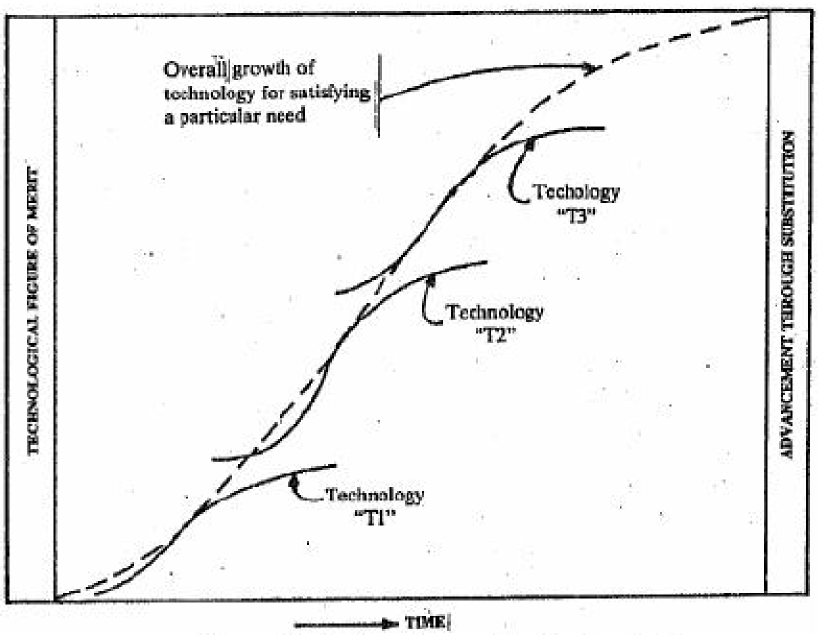

Figure it : S-shaped growth of technologies

Source: Technology for Development)UN-ESCAP,1948.

The hardware intensive technology diffusion process can be considered to consist of five phases (Figure 2.2). The first is the 'incubation phase' where many ideas are gradually reduced to one commercial product for introduction into the market. Next, is the 'introduction phase' where the applications of the new technology are very slow. Later when the number of applications increase rapidly, the technology is in its "growth phase". After sometime its growth reduces and some stability can be observed in the `maturity phase'. Finally, an improved substitution makes the technology obsolete, and hence it enters the `decline phase'. It may be noted, however, that time taken for these different patterns varies widely. The introduction, growth and maturity phases of a technology are also referred to as the three major stages of 'Technology Life Cycle'.

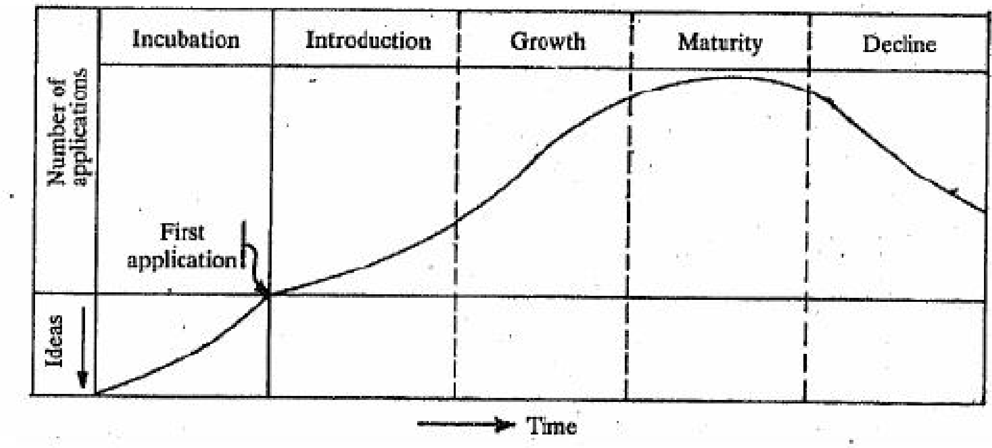

Figure 2.2 Phases In the technology diffusion process
Source: Technology for Development, UN-ESCAP,1984p7.

Activity 1
Discuss the "Technology Life Chain" of any one of the processes or products concerned with your organisation or any other you know of, indicating the stage of the technology at which the products or processes are located.

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2.5 TECHNOLOGICAL TRANSFORMATION

It is recognised that it is neither possible nor desirable to try to develop technology in every sector when one talks of building up indigenous technology. Nevertheless, it may highly desirable that in carefully selected areas of production there is a vertical integration with respect to all stages of technological transformation necessary to put a product on the market, starting from the natural resources.

A schematic presentation of the stages of technological transformation in the production of goods is presented in Figure 2.3. The presentation is simplistic and it only illustrates the basic point of technology planning. Everything starts from nature and eventually goes to the market. In between there are five major stages of transformation. The first stage is called the 'collective stage' and includes such operations as extracting, mining and farming. Stage two can be called 'refining stage' and includes operations such as purification, preservation and metallurgy. `Processing' can be deemed as third stage where chemical and electrical conversions take place. The fourth stage is the `manufacturing stage' which refers to all kinds of mechanical conversions and fabrications. The last stage is `packaging stage', where things are assembled and packaged for dispatch to the markets. There are considerable variations in the technology content added to the product at each of these five stages.

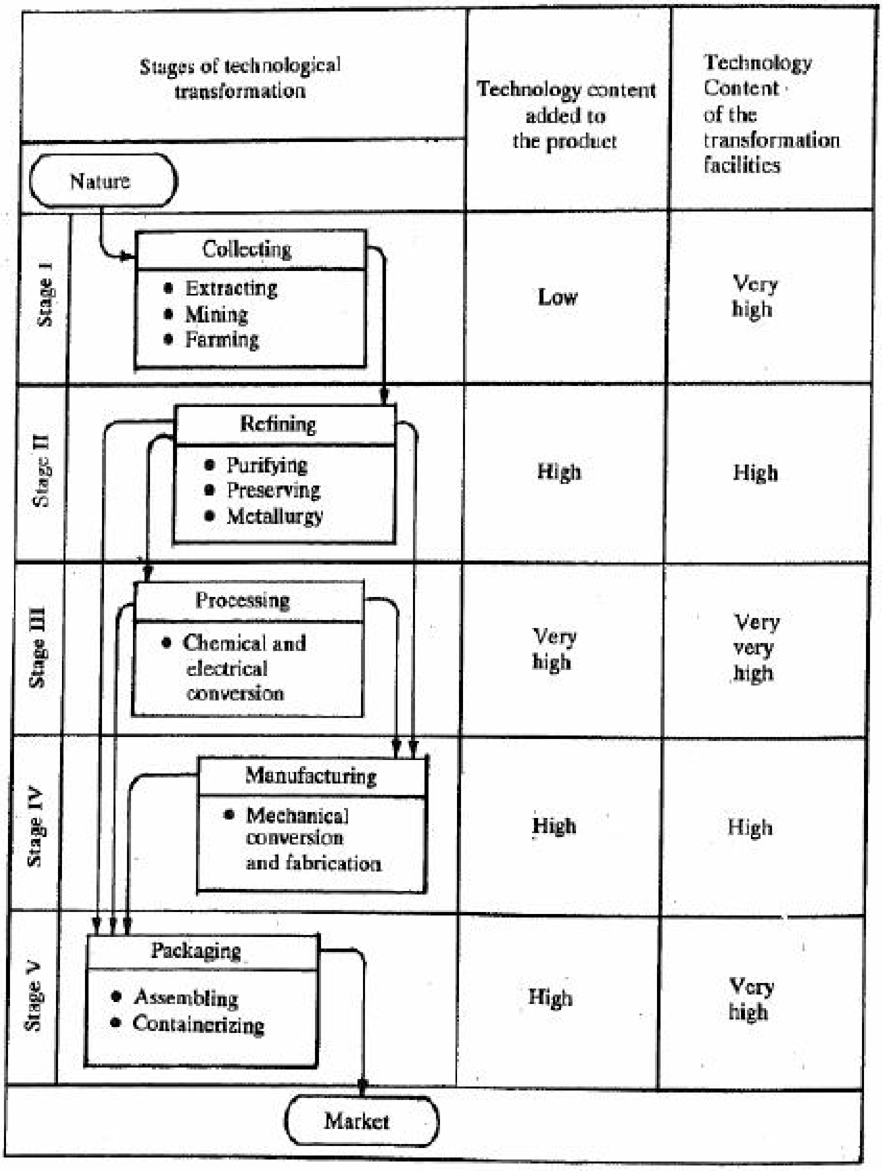

Figure 2.3 : Five stages of technological transformation in the production of goods
Source: Technology for Development UN-ESCAP,1984 p 11.

Activity 2

Identify the stage of technology transformation of a product/process manufactured by your company or any other company you are familiar with, and give the reasons.

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2.6 TECHNOLOGICAL ALTERNATIVES

Nations that spend relatively large amounts on R&D in an industry tend to be relatively quick in reaping the benefits of new technology, even though they may not be the original innovators. Both for nations and the individual firms, R&D provides a window to developments in various parts of the outside world, enabling the nation or the firm to evaluate external developments and react more quickly to them. For the developing countries most important question is that of making strategic choices regarding the areas of specialisation. This is a complex task because of innumerable choices and alternatives for each area of technology. To illustrate, in the area of energy and materials technology, alternative objectives can be: more efficient use of energy or materials; natural resources surveys; new and renewable energy resources; non-conventional sources of energy; widening the raw materials base, conversion and recycling of raw materials.

The alternative field of activities can be: production of consumer services with less consumption of energy and raw materials, evolutionary replacement of metals and alloys by ceramics, composites and polymers, anti-corrosion through surface treatment, coal utilization including gasification; construction materials, etc.

2.7 APPROPRIATE TECHNOLOGY

Technology is a product of an R&D centre outfit or establishment. However, different R&D centres produce different technologies for achieving the same or similar goals. This is because of differing environments and surroundings and other conditions, *viz.,* population, resources, economic, technological, environmental, socio-cultural, and politico-legal systems. The objective functions used in the development of technology could also be different at different places.

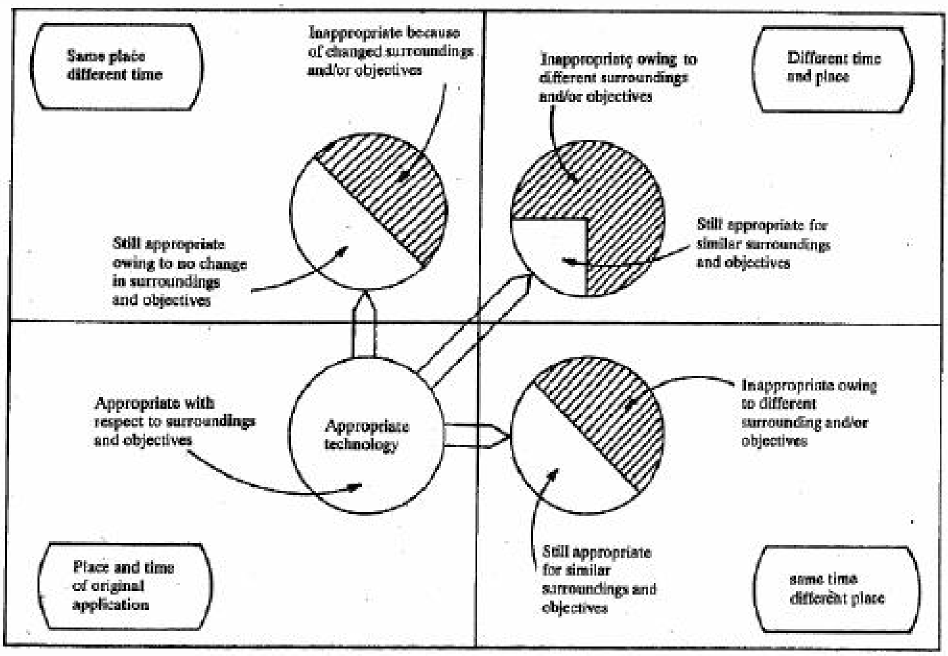

Figure 2.4: Appropriate and inappropriate technologies

Source: Technology for Development UN-ESCAP,1984, p87.

Figure. 2.4 illustrate the concept of appropriate and inappropriate technologies. Any technology is 'appropriate' at the time of development, with respect to the surroundings for which it has been developed, and in accordance with the objective function used for development. It may or may not be appropriate at the same place at a different time, because the surroundings and/or objective functions may have changed. Similarly it may or may not be appropriate at a different place at the same time, or at different times, because the surroundings and objective function may be different. Thus, technological appropriateness is not an intrinsic quality of any technology, but it is derived from the surroundings in which it is to be utilised and also from the objective function used for evaluation. It is, in addition, a value judgement of those involved.

The surroundings differ not only from place to place but also over time. With the passage of time and application of technologies almost all elements of the surroundings change for better or worse. Although in general two surroundings are unlikely to be identical, for any particular technology many apparently different surroundings may in fact be considered similar.

The following examples will illustrate the concept of appropriateness of technologies:

1) DDT was an appropriate pesticide at the place and time of original application. However, after sometime it became inappropriate even at the place of origin and the pesticide is banned in industrialized countries. DDT is still considered to be appropriate in many developing countries as the specific surroundings and objectives are collectively judged to be similar to those of the place and time of original application.
2) Coal based technology for power generation was very appropriate at one time, but became inappropriate due to technological substitution process. Now with further change in the surroundings (with respect to resource aspect particularly) the coal-based technology has become appropriate again. Because of the changes in the surroundings, technologies once labelled inappropriate can become appropriate technologies in the future.
3) Technologies such as electric tooth blush, cable cars etc. are appropriate only in a few places and inappropriate in many other places because of the surroundings.
4) Technologies embodied in drugs, such as, antibiotics, vaccines, contraceptive pills are appropriate all through the world because the specific surroundings include mostly human body and, therefore, are somewhat similar.

Some of the accepted criteria for selecting appropriate technologies in the contemporary situation are considered below:

- It should primarily aim at meeting the basic needs of rural people; it should be capable, of absorbing large labour force, preserve existing traditional jobs, low cost and require low levels of skills;
- It should provide viable means for small-scale production operations.
- It should consume lesser energy;
- It should be capable of using indigenous raw materials and services;
- It should provide for waste recycling and should be non-polluting;
- It should be consistent with local culture;
- It should be compatible with social system,
- It should be acceptable to the political system.

Activity 3

Do you think the products/processes with which your organisation is concerned are based on Appropriate Technology? Give reasons.

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2.8 TECHNOLOGY POLICY AND POLICY INSTRUMENTS

The need for technology policy springs from an explicit commitment to a national goal and the acceptance of technology as an important strategic variable in the development process. Technology policy formulation ought to naturally follow the establishment of a development vision or perspective plan. This plan is characterized, among others, by a desired mix of the goods to be produced and services to be provided in the country in the coming one or two decades. The formulation of a technology policy begins with the establishment of a vision for the country and the corresponding scenario of the mix of goods and services to be produced and provided. The policy framework has to be broad and flexible enough, taking into account the dynamics of change.

A technology policy is a comprehensive statement by the highest policy making body (Cabinet/ Parliament) in the Government to guide, promote and regulate the generation, acquisition, development and deployment of technology and science in solving national problems or achieving national objectives set forth in the development vision or perspective plan.

The principal aims and objectives of a technology policy are to acquire the technology and essential technological capabilities for the production of goods and services as envisaged or set forth in the vision for the country. The policy statement includes the expression of a desire to develop a national capacity for autonomous decision-making in technological matters. The policy document includes the principles on which the envisaged technological development is to be based. Such principles include, among others, considerations of preservation and improvement of environment, satisfaction of basic needs, promotion of self-reliance, creating mass involvement, etc.

The technology policy declaration usually contains several commitments on behalf of the Government and some categorical assurances. The policy, among other things, commits the authority to ensure:

- Establishment of institutional facilities for relevant knowledge dissimination and skill development for stepwise absorption of imported technology.
- Provision of facilities for productive utilisation of research results and generation of indigenous technology.
- Development of support facilities like information and documentation services, standardisation and quality control.
- Adequate support to emerging technologies with an eye on future utilisation in production sector.
- An optimal blend of indigenous and imported technology.

The Indian Government had announced a comprehensive Technology Policy Statement in 1983, the details of which are given in unit 10.

Policy Instruments

Policy instruments are the links between the expressed purpose and the results that are sought in practice. There are both direct and indirect policy instruments. The direct ones refer explicitly to technology functions and activities. The indirect ones, although primarily referring to policies, functions or activities other than technology, have an important indirect effect on S&T activities. A policy instrument is a complex entity and may directly or indirectly affect activities or influence the results of resource deployment. Different policy instruments are listed below:

- Policy instruments to build up S&T infrastructure a Policy instruments to regulate technology import.
- Policy instruments to define the pattern of demand for technology.
- Policy instruments to promote the performance of S&T activities in the enterprises.
- Policy, instruments to support the performance of S&T activities.

Technology policy influences the activities of different segments, agencies or departments of the government and has a direct bearing on various sectors of the economy. The formulation of a technology policy is further complicated by the necessity of its integration with the national development policy. The policy formulation mechanism would vary from country to country depending on its social values, political system and prevailing economic conditions. Technology policy formulation largely depends on the political will of the government to take the initiative. The government may ask an advisory body/committee/ministry to draft an S&T policy which may lead to an S&T Plan for integration into a national socio-economic plan. In India the Science Advisory Council to the Prime Minister and the Cabinet are the S&T policy-making bodies. The policies are implemented through the various departments in the Ministry of Science & Technology and other S&T and Technical Departments.

Activity 4

Attempt as suggested below:

i. First, gather the information regarding recent changes in the industrial policy which have a bearing on the flow of technology into India.

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ii. Then, arrange a meeting with a knowledgeable person of your organisation and discuss with him how *these* changes would affect your organisation, in the short and the long run.

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2.9 TECHNOLOGY PLANNING

With the emerging role of technology as a masterkey for development, 'integration of technological considerations in the national socio-economic development , planning process and strengthening of national capabilities for effective importation,

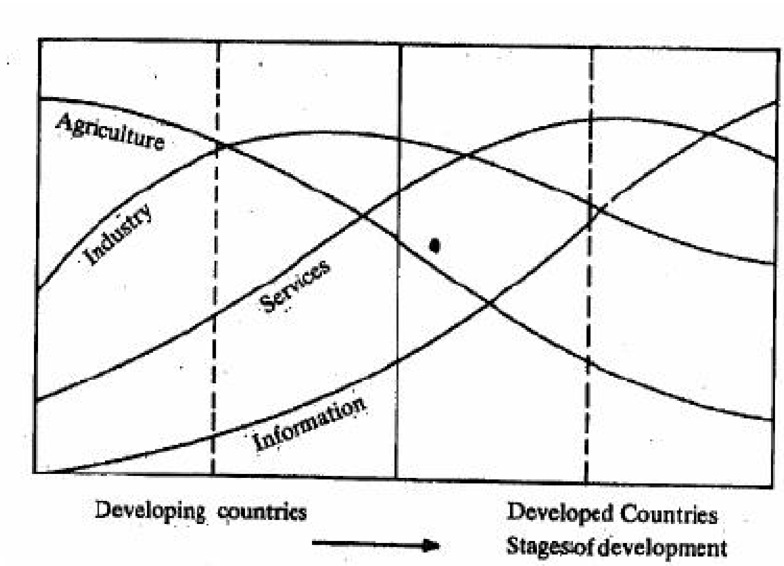

Figure 2.5 : Changes in the structure of the economy with technological advancement
Source: Technology for Development UN-ESCAP, 1984, P26.

generation and utilisation of technologies have become imperative. There are no unified technology planning procedures; however, the objectives of technology plans are usually expressed as under:

a) Importation, adaptation and modification of technologies produced elsewhere.
b) Advancement of technology development capability in the country.
c) Creation of a climate for the acceptance of the need for technological change.

Common procedures followed include macro level planning, micro level planning and project level planning. Several problems are normally experienced in the procedure. At the national level there is a dominant concern regarding the unemployment aspects of technological change. It is important to realise that all processes of modernisation and change result in some structural unemployment. The employment situation changes continuously with the advancement of technology (Figure 2.5). Therefore, it is essential to explore opportunities for achieving structural changes and expansion of the base of production facilities.

Some of the important points for effective technology planning at the national level are as under:

a) It is essential that the planning for technology should be kept as a dynamic process.
b) Shift from import substitution of consumer goods to capital goods and then import substitution of technology itself which is a difficult one and requires careful planning.
c) The dimension of time is particularly critical for technology development; development of technological capabilities requires a long gestation period.
d) In the early stages of development, protection of local technological efforts is essential, but this should gradually be withdrawn.
e) Fostering competition and market orientation is very important for technology development.
f) The will to solve one's own political and administrative problems and financial commitments at the highest national level is a necessary precondition for the preparation of any useful technology plan.

2.10 TECHNOLOGY DEVELOPMENT OPTIONS AND STRATEGIES

For all the countries, the most practical strategy for technology development-is to `make some and buy some'. This gives the advantage of selecting an appropriate area of specialisation and the potential to exploit the technology trade in the international market place.

The complex process of technology development is schematically presented in Figure 2.6.

The technological needs are derived from national socio-economic goals. A country's technology development strategy is then determined by combining these identified technological needs with potential technological developments in the world and a thorough assessment of available and emerging technologies. Then the Country determines a strategy to import technologies, which it cannot practically develop itself and identifies technologies, which can be produced locally. Now, there is a universal realisation that unless a concerted attempt is made to build local technological capabilities for absorbing imported technologies, any attempt to develop indigenous technologies encounters enormous difficulties. Even with regard to imported technology, it is essential for a country to be able to select, digest, adapt and improve it for local consumption. All of these efforts justify greater priority and allocation of resources to R&D. A pre-requisite for effective utilisation of R&D resources is the 'development of technological infrastructure within the country, including institution building, manpower development, provision of support facilities and creation of an innovative climate.

The following general principles with regard to the planning for development of indigenous technological capabilities may be kept in view:

i) It is important to be selective in self-development of technology. Emphasis should be given to total integration of all activities in the technology production chain to achieve self-reliance.

ii) In selecting areas for development, a country can be inward looking in some areas and outward-looking in some other areas.

iii) Import substitution can only be a temporary strategy.

iv) In the technology production chain, a number of activities involving basic and applied research can be undertaken, but it is important to be able to discard some of the non-productive projects and concentrate, from time to time, upon those which have high commercial potential.

v) Technology development is best achieved through collective effort. Individuality, which tends to aim at being unique rather than practical, should be minimised.

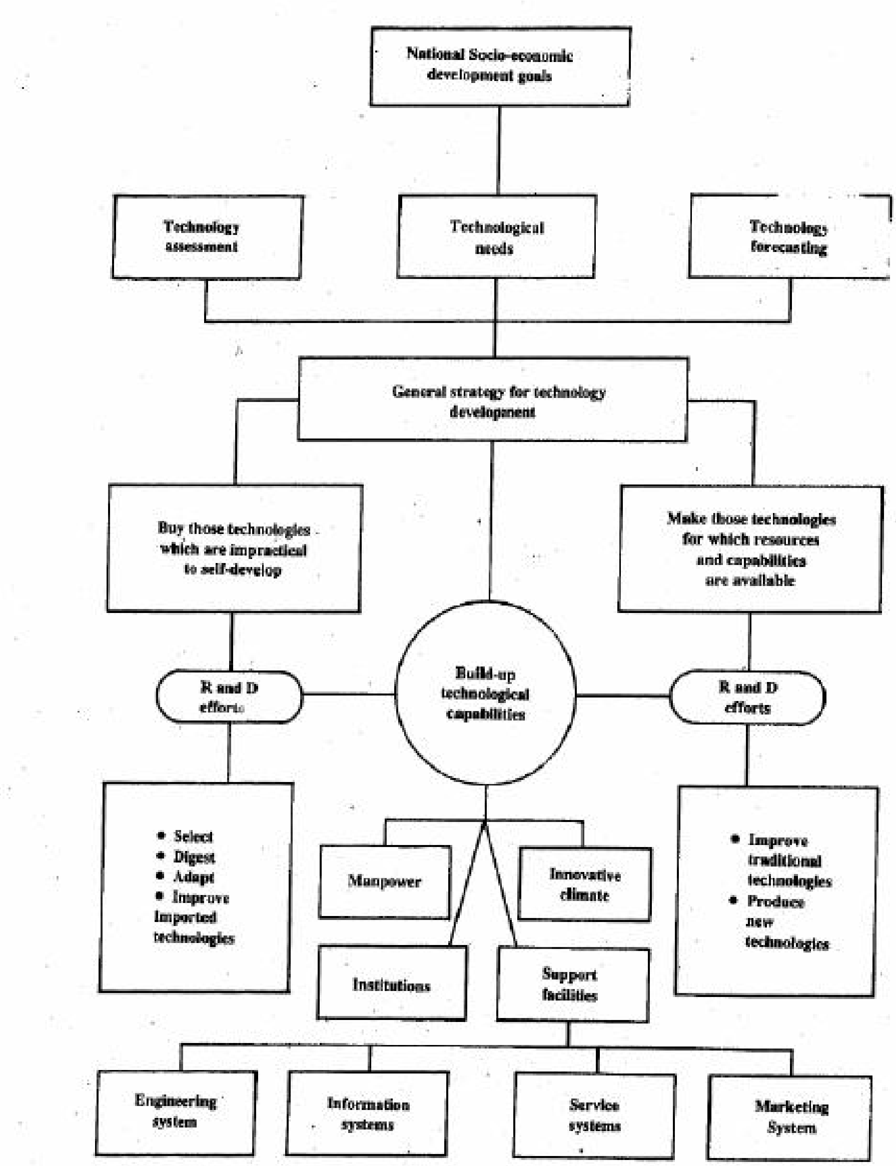

Figure 2.6 : The process of Technology Development

Source: Technology for Development, UN-ESCAP 1984, p: 30.

Activity 5

What kind of Technology Development Strategy is followed in your organisation or any other organisation you are familiar with? Discuss the merits and demerits of the strategy.

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2.11 TECHNOLOGY AND SOCIO-ECONOMIC PLANNING

Successful integration of technological considerations into the socio-economic planning process is very essential. It is necessary that the national development strategies should include specifically the dimension of technology development. In developed countries there are adequate pressures for technological considerations within the various sectors of their economies. But in developing countries; integration of technological considerations with economic planning at the highest level is required in order to achieve technology-oriented development in priority sectors. Figure 2.7 presents a general framework for integrating the technological considerations in the national development planning process.

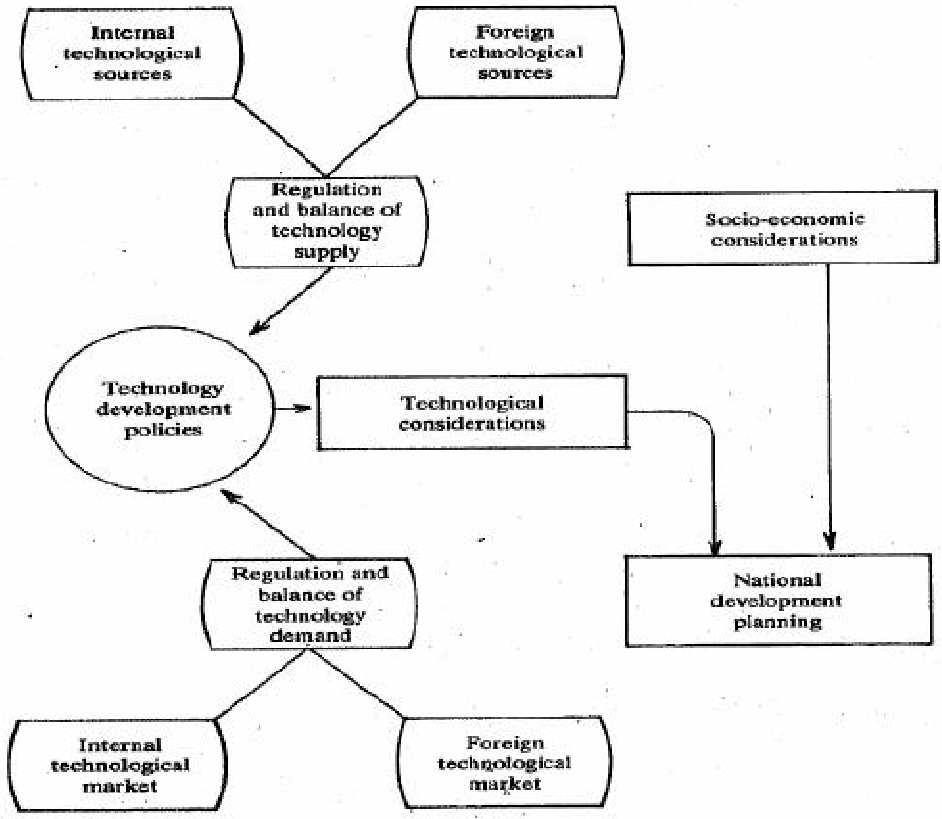

Figure 2.7 Integration of technological comdderetionu in national development planning
Source: Technology for Development, UN-ESCAP, 1984, R34.

The integration of technological aspects should extend significantly beyond mere screening of imported technologies to the formulation of policies and guidelines. They must be directed to generate and promote demand for local technologies and technological capabilities. Moreover, the insertion of technological considerations in socio-economic development planning involves both the explicit introduction of the technology issue at all phases of the planning process and identification of implicit technology policies derived from the national development plans.

2.12 SUMMARY

Technology and its development is vital to the economic growth of a nation and its enterprises. Therefore, it is important to understand the various aspects related to technology. The aspects discussed in this unit include: technology life chain; diffusion and growth of technology, appropriate technology, technology policy and policy instruments, technology planning, and development options and strategies. Appropriate technology is a function of requirements at a given point of time in a given environment, and several options are available to an enterprise to acquire such technologies, which would call for a strategy at corporate level. Technology planning and its linkage with social system is also important at national as well as enterprise level. The other aspects include technology financing and financial returns, technology audit, technology assessment and forecasting, technology information systems, technology transfer mechanisms, technology intelligence, intellectual property systems, and so on. Many of these aspects have been discussed in detail in other units of this course. Technology management involves the knowledge and appreciation of all these aspects at the enterprise level, to remain competitive and to achieve sustained growth.

2.13 KEY WORDS

Technology Life Cycle: Denotes a period of time during which a particular technology after it has been introduced becomes obsolete or is overtaken by a newer technology, and hence its utility or returns start declining.

Technological Transformation The processes and/ or activities that transform materials and components to usable products and services.

Appropriate Technology: A technology that is appropriate at a given point of time for a given requirement under a set of conditions.

Technology Planning: Identification of future strategies and measures for development, acquisition and use of technologies consistent with national considerations.

Technological Needs and Strategies: Technological needs are derived from national socio-economic goals. Technology strategy is determined by considering the identified needs with potential technological developments and an assessment of available technologies consistent with country's capabilities or resources.

2.14 SELF-ASSESSMENT QUESTIONS

1) Define and explain the process of technological change and technology life chain.
2) What is appropriate technology? Discuss its various aspects and critically comment on the concept.
3) Discuss some of the aspects and issues concerned with technology. Discuss the relevance of any two aspects with special reference to your organisation.
4) Comment on the role of technology in socio-economic planning.
5) Discuss various factors that may govern the choice of a particular technology out of the various available alternatives. Illustrate with a suitable example.
6) Discuss the role of technology policies and policy instruments in achieving industrial and economic developmental goals.
7) What could be the possible options for technology development an -acquisition at the enterprise level? Discuss with reference to your own organisation or any organisation you are familiar with.
8) Discuss the role of Technology Policy and Policy Instruments with reference to Technology Management at enterprise level.

2.15 FURTHER READINGS

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UNIT 3 IMPLICATIONS OF TECHNOLOGICAL CHANGE

Objectives

After studying this unit, you should be able to:

- understand the meaning of technological change and its effect on factor substitution;
- identify the nature of technological change and categorize it in terms of its magnitude;
- appreciate the impact of Information Technology on products, services, processes and organisations; and
- recognise the macro-effects of technological change.

Structure

3.1 INTRODUCTION

Almost all of us, in our own generation, have seen many technological changes that have affected our day-to-day functioning and the production of goods and services. However, the moment we get down to precisely defining technological change or measuring it, we are immediately faced with a host of difficulties, including conceptual ones. For example, would the process of mechanisation or substitution of labour with capital qualify as a technological change or does technological change encompass changes in product design as well? In this unit we would like to evolve a broad understanding of technological change and develop a framework, which should enable us to delineate the implications of technological change clearly.

Technological change has been defined broadly as `the process by which economies change over time in respect of the products and services they produce and the processes used to produce them" and more specifically as alteration in physical `processes, materials, machinery or equipment, which has impact on the way work is performed or on the efficiency or effectiveness of the enterprise'[2]. Technological change may involve a change in the output, raw materials, work organisation or management techniques but in all cases it would affect the relationship between labour, capital and other factors of production. Therefore, we shall begin by reviewing the concept of technological change as presented in the introductory textbooks of Economics.

Activity 1

List three technological changes that you have observed over the years and the major effects of each of these changes

	Technological Change	Major Effects
1)	....	....
	....	....
	....	....
2)	....	....
	....	....
	....	....
	....	....
3)	....	....
	....	....
	....	....

3.2 PRODUCTION FUNCTIONS AND TECHNOLOGICAL CHANGE

A production function attempts to specify the output of a production process (as a function of the various factors of production e.g., labour, capital, technology, management or organisation and land). It may be possible to explicitly state the nature of this function based on econometric studies but that is not our interest at present. We would like to understand the role of technology in the production process and for that purpose we would like to begin with the isoquant approach. An isoquant specifies a range of alternative combinations of two factors of production, say labour and capital, which can be used to produce a given quantity of the output and is based on the assumption that the other factors of production e.g. the state of knowledge of technology is constant.

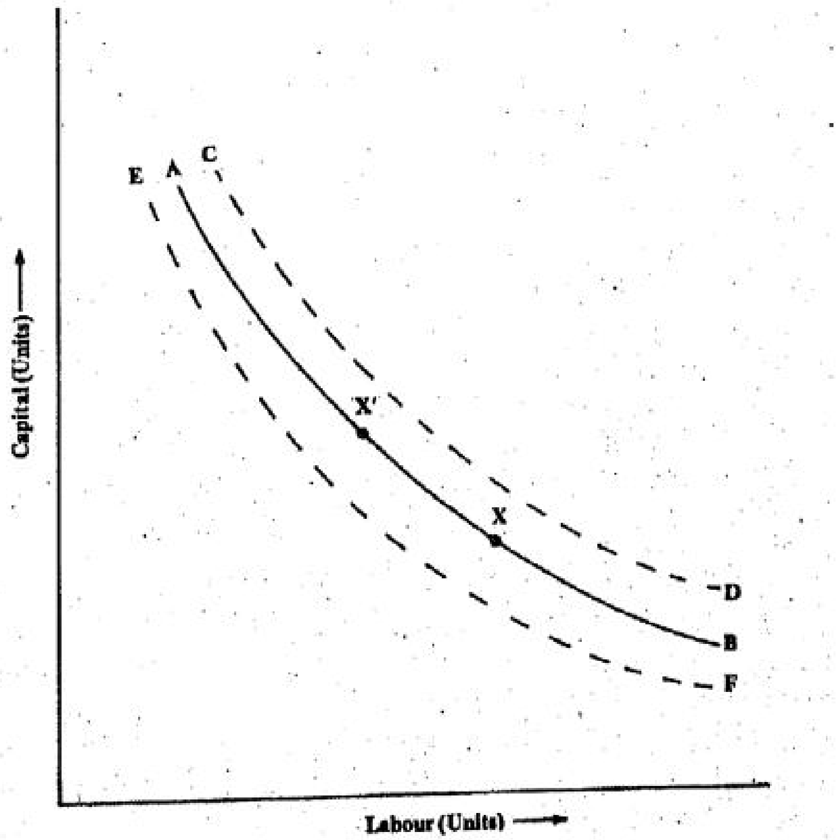


Figure 3.1 : Isoquants and factor sunsututton

In Figure 3.1 above AB is an isoquant representing various combinations of labour and capital that could be used to produce a specific quantity of the product. If we want to produce a higher quantity of the product, another isoquant can be drawn to represent the various combinations of labour and capital that could be used for the same. Here CD represents such an isoquant and, as is expected, is above AB since the marginal product of both labour and capital is assumed to be positive in the ranges shown. Similarly, EF is another isoquant and because it lies below AB, it represents an output level lower than that of AB.

All of these isoquants are drawn for the same level of technology and for the given level of technology, an isoquant represents the possible substitution of labour by capital or vice-versa. In this approach, therefore, if the relative prices of labour and capital are known, one can find an optimum mix of labour and capital to minimise the total cost of production. The textbook expositions usually represent isoquants as smooth curves as shown in Figure 3.1 above, which would imply, at least in theory, that even small changes in factor prices would induce factor substitution to restore optimal conditions. Thus, a change in factor prices would result in a movement along the isoquant AB-e.g. From X to X' in Figure 3.1, whereas a change in technology would result in a shift in the isoquant, e.g. from AB to A'B' as shown in Figure 3.2 below.

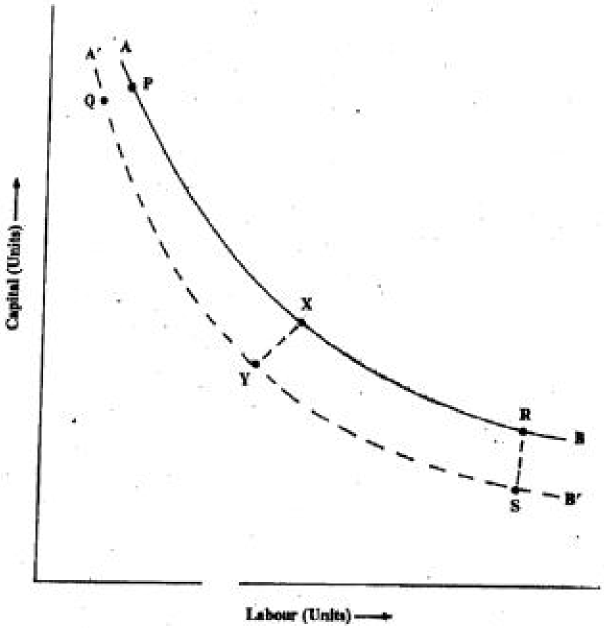


Figure 3.2 : Isoquants and Change in Technology

A closer look at Figure 3.2 would reveal that the technology used to get the isoquant A'B' is superior to that used before the change in technology. However, the corresponding shift in the optimal point from X to Y is, more difficult to interpret. Given the relative factor prices, point X minimises the total cost of production with the existing technology (relevant for the isoquant AB) whereas point Y minimises the total cost of production with the improved technology (relevant for the isoquant AB'). The difficulty in conceptualising smooth production functions and consequently smooth isoquants - now gets clear. For example, it is not at all obvious from Figure 3.2 above whether the improved technology is labour-augmenting or capital augmenting.

Suppose the factor prices were such that the optimum was at P on AB in Figure 3.2. It would appear that the shift in the optimal point from P to Q as a consequence of the change in technology has been mostly of the labour-augmenting type since the labour efficiency has improved much more than the capital efficiency. On the other hand, if the factor prices were such that point R on AB was the optimal point and it shifted from S to S as the technology changed, it would appear that the change in technology has mostly been of the capital-augmenting type. In other words, the change in technology can manifest itself as either labour- or capital-augmenting type depending upon the factor prices.

A smooth isoquant also implies that there are many (theoretically infinite) combinations of labour and capital at any given level-of technology and so any change in factor prices is immediately reflected in a new optimal mix of labour and capital. This is not generally borne out in practice. In practice, we find that the mix of labour and capital is relatively insensitive to short-term changes in factor prices and is quite well defined for a given level of technology. Similarly, a change in technology is usually associated with a different mix of labour and capital. For example, manufacturing of sugar and khandsari require different mix of capital. It should be pointed out that these mixes of labour and capital are determined more by long-term changes (and expectations of changes) in factor prices than by short-term fluctuations. A smooth production function is incapable of explaining these realities. If we change our assumption that the amount of labour and capital can be mixed in an infinite number of alternative proportions (as indicated by an isoquant of the type 'shown in Figure 3.2 above) and assume the other extreme possibility, i.e., that the proportion of labour and capital is predetermined at a given level of technology and is totally immune to any changes in factor prices, we can then show the effect of changes in labour, capital and technology on the same graph as shown in Figure 3.3 below. Each point on the production function represents one process of producing the product and associated with each of these processes is a certain technological knowledge specific to that process. Figure 3.3, for example, shows that there are two different processes available to produce the product under discussion represented' by points A and B -one being labour intensive (viz. B) and the other capital intensive

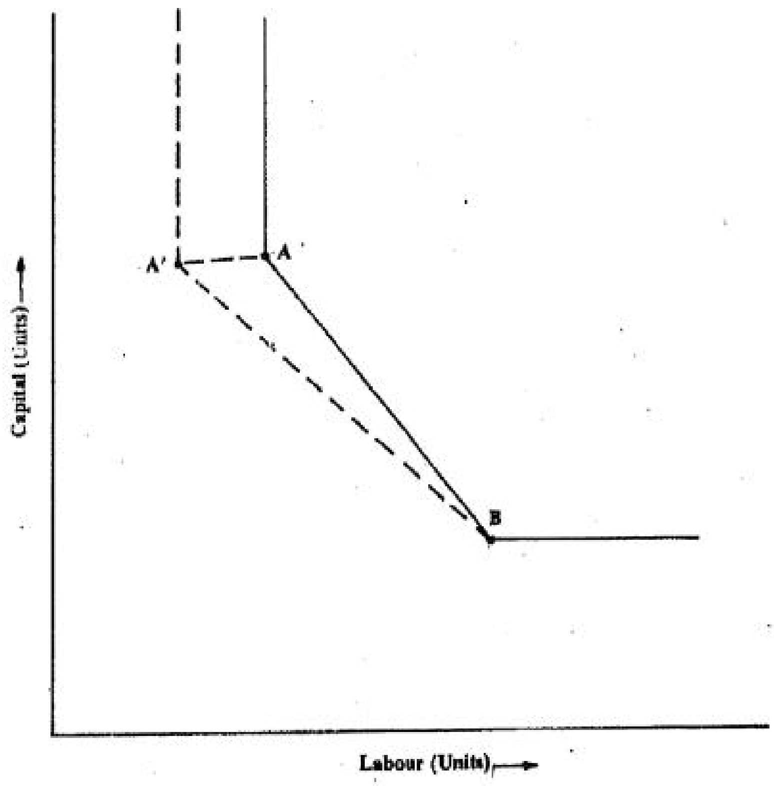


Figure 3.3 : Production Function with no Factor Substitution

(viz. A). Given different factor prices, each of these processes can be economically viable in different economies. In developed countries, for exmaple, labour is relatively more expensive and hence, capital, intensive technologies are preferred. The line AB is still similar to an isoquant as the combinations of labour and capital represented by points A and B would produce the same quantity of output. Much of the technological change is based on the accumulation of technological knowledge about specific processes. So a change in technology is quite often reflected by a shift in the production function from AB to A'B ambiguous whereas the shift from A to A' is associated with a change in technological knowledge specific to the capital intensive process above. This gives rise to a further reduction in the use of units of labour required to produce the same number of units of output. It has been established in many empirical studies[3] that a choice of technology does exist in the manufacture of many products, although the number of such alternatives may not be as high as perhaps suggested by continuous production functions. Also, the change in technology in terms of both the development of new knowledge as well as its application appears to be induced by long-term movements of factor prices and not so much by short-term fluctuations.

3.3 NATURE OF-TECHNOLOGICAL CHANGE

We would like to categories various types of technological change after Freeman.

This is necessary to understand the nature of technological change in general and its social implications in particular. Freeman has categorised technological change into the following four categories:

Incremental Innovations : These are small and marginal improvements brought about by individual units and firms out of the experience of working with the specific process or the product. These generally give rise to productivity improvements or better products/process resulting in lower costs. Although each single incremental innovation may have relatively insignificant effect on the productivity or the cost, the cumulative effect of many of these innovations taken together may result in significant improvements. Also some of the management techniques like work study, organisation and methods (0 & M), value analysis, etc. are used on specific processes with the objective of productivity improvement and cost reduction and most of them would actually result in accelerated incremental innovations. The R&D efforts in India have often resulted in incremental innovations e.g., developments in auto industry.

Radical Innovations: These are major changes in the process or the product generally brought about by formal research and development efforts. Radical innovations are disjointed events, difficult to predict and have a substantial effect on productivity, cost and the quality of the product. Consequently they act as catalysts for the growth of new markets. The development of a "Jumbo" passenger aircraft, or one with supersonic speed would fit in this category, as would the development of so many new drugs. Sometimes, a whole cluster of radical innovations develops, interlinked with each other, giving riseto the creation of new industries and services. In our terminology, such technological changes would belong to new technological systems described below.

New Technological Systems: Some of the radical innovations, in course of time, end up developing an entire cluster of many radical innovations interconnected with each other both technologically and economically, thus creating an entire new industry. The cluster of petrochemical innovations finally created a petrochemical industry and the cluster of synthetic materials innovation similarly gave birth to the synthetic materials industry. It is to be noted that the various radical innovations forming part of a new technological system are connected not only technologically but also economically.

Technological Revolutions: These are technological changes that are all pervasive and affect many (or even all) branches of the economy through product innovations, process innovations as well as organisational innovations. They have also been described as changes of techno-economic paradigms as they affect the techno economic viability of existing product and process designs. They have the capability of changing the `best practice' set of rules and customs for designers, engineers, entrepreneurs and managers from the previously prevailing paradigm. Such changes have the potential of increasing productivity by quantum jumps. However, the gains in productivity are initially achieved in only some of the leading sectors and' it takes decades of learning, adaptation, incremental innovation and institutional change before they are realised throughout the economy. Development of semi-conductors and microchips is an example of this type.

Changes in techno-economic paradigms produce in their wake a new generation of new and improved products and services as well 'as a new range of capital equipment for all sectors of the economy. These changes offer scope for new employment-generating investment as well as large productivity gains from savings in practically all factors of production.

Let, us very briefly take a look at one such technological revolution, the availability of electric power as a source of energy for industrial use. Figure 3.4

summarizes the chronology of electrification of industry and it is apparent that this process took many decades to complete. Although many of the radical innovations took place in the 1880s, the major economic benefits of electrification came much later as shown by the gradual rise in the share of electrification. It was not until after 1900 that the indirect benefits of electric drives like greater flexibility in factory layouts and higher utilisation of floor space were realised (to be important by themselves as compared to the direct benefits in terms of energy saving capability of electric drives). In course of time, electrification has made possible many new products and new processes and has taken economies through employment-generating investments giving rise to significant productivity increases at the same time. Technological revolutions have the capability of creating new industries. Although the employment in existing industries may reduce or record slower growth due to higher productivity, the net effect on employment in the whole economy is positive if the investments in the newer products and processes are forthcoming. Development of biotechnology in recent times is yet another example which has revolutionized almost all sectors ranging from medical to agriculture.

It is very important to understand the implications of technological revolutions as they also act as the launching pads for the other three categories of technological change. For this purpose, we take a closer look at the technological revolution currently sweeping our economies, viz., that of Information Technology, in our next section.

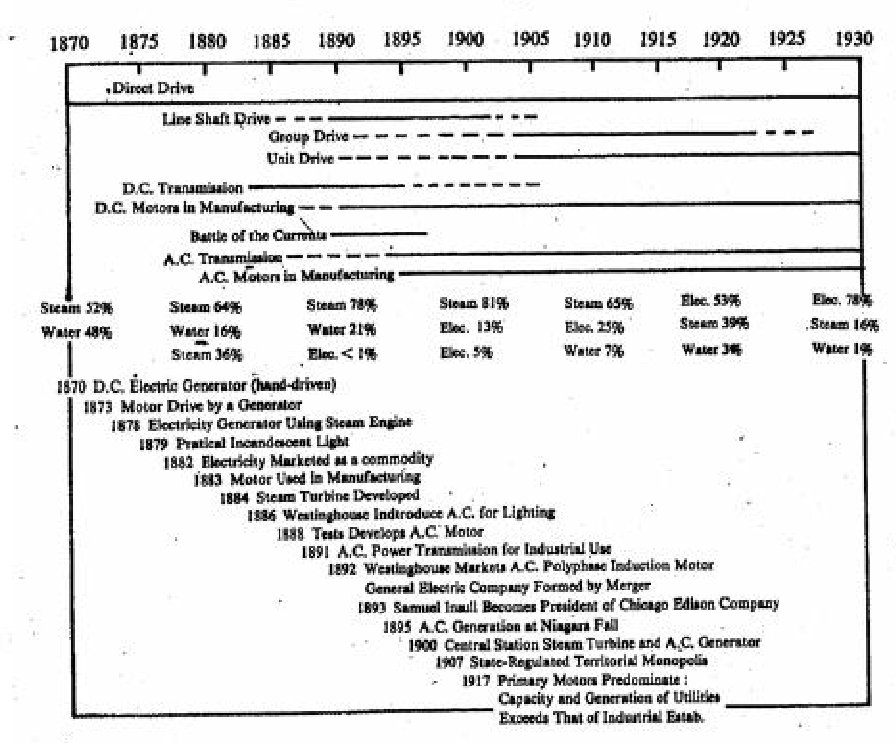


Figure 3.4 : Chronology of,electrification of industry a (a) methods of driving machinery; (b) rise of alternating current; (c) share of power mechanical drive provided by steam, water, electricity; and (d) key technical and entrepreneurial developments

Source : Warren Devine, 1983; From shafts to wires, Journal of Economic History, 43, No. 2

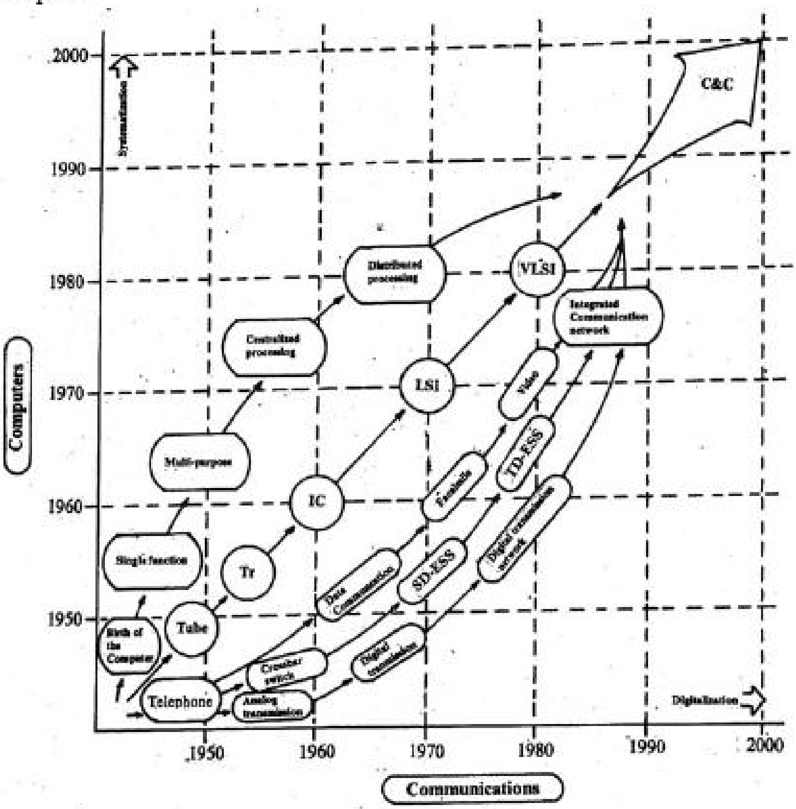
Activty 2

Give an example of each category of technological change from your own experience:

Category	Example
Incremental Innovation	....
Radical Innovation	....
New Technological System	....
	....
Technological Revolution	....

3.4 INFORMATION TECHNOLOGY REVOLUTION

Information Technology synthesises the convergence of previously distinct and separate technologies. As is clear from Figure 3.5 below, developments in computer



Tr = Transistor
IC = Integrated Circuit
LSI = Large Scale Integration
VLSI = Very Large Scale Integration
SD-ESS = First Generation Electronic Switching Systems TD-ESS =Second Generation Electronic Switching Systems C&C = Computers and Communications

Source : Kobayashi, Koji, "The Japanese Telephone Industry in the Year 2000" in International Telecommunication Union (ITU), 3rd World Telecommunication Forum, Part 1, p. 11.6.4., ITU, Geneva, 1979.

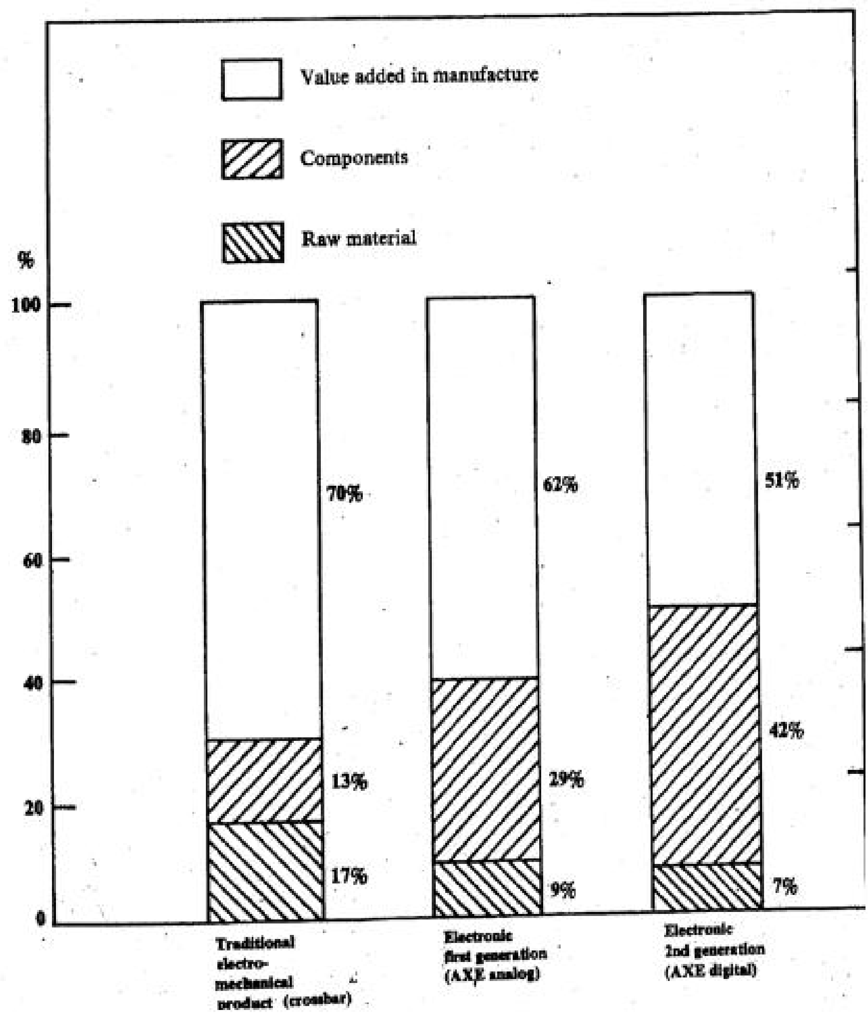
Figure 3.5 : Convergence of Components, Computers and Communications

technology, electronic components technology and the communications technology along with appropriate software have converged and are now known by the catchword Information Technology' (IT). Information Technology refers to `a very wide range of elements which are utilised to create, transfer, transform and convey information through means, irrespective of whether these elements are in the form of equipment, services or know-how'. Developments in information technology have already produced vast gains in productivity resulting in counter-inflationary trends in prices as well as substantial improvements in technical performance of many products and services.

Information technology is all-pervasive as it affects all, activities that contain some form of logical function. The source of the activity could be mechanical, electrical, pneumatic, hydraulic or even intellectual. Information technology cuts horizontally across clerical, supervisory, managerial and communication activities, which are common to all sectors of industry and also affects the design of products and services, processes and organisations producing the same. We shall now discuss some of the major changes brought about by developments in information technology.

Changes in Products

Information technology brings about changes in products by replacing mechanical (e.g. watches), electromechanical (e.g. calculators) or older electrical or electronic



Source : Lamborghini, B., "The impact on the enterprise", in Friedrichs, G. and Shaft'. A. (eds.), Microelectronics and Society. For Better or For Worse Report to the Club of Rome, Pergamon Press, Oxford, 1982, page 130

(e.g. computers) parts or components, by upgrading traditional products by enhancing their capability. It includes functions involving, for example, logic and decision-making (auto focus in cameras) and even by creating entire new products (e.g., video games).

The product changes mentioned above have three major consequences. The first is that the value addition is transferred from the manufacture and assembly of parts to the production of the electronic assemblies/sub-assemblies with associated software as shown is Figure 3.6 for the telephone switching equipment as an example. Juxtaposed is the fact that the manufacture of electronic component-based systems can have very low labour intensity (labour per unit of capital). The picture that emerges suggests that the labour intensity of such products decreases with further consequences in terms of employment as well as location of the manufacturing plants.

The second effect relates to ***shortening of product life cycles.*** Product design of many products get linked to developments in information technology in general and to developments in electronic technology in particular. Because there are very fast developments in these technologies, they have their effect on the design of newer products, thus shortening their product life cycles. As a convergence technology, IT acquires the ability to condition developments in an ever-increasing number of sectors of the economy.

The ability to create, store, retrieve, transfer, transform and convey information/data efficiently and economically (imparted to products by developments in information technology) allows the products to the ***integrated into larger systems*** *so* that the products are compatible with the larger systems tor enhanced capability. For example, electronic-typewriters cannot only type but also store the, typed information for later processing on a microcomputer and so compatibility with microcomputers will be one more feature to be built into electronic typewriters.

Changes in Services

We use the term "services" in its broadcast sense as ***bundles-of benefits some of which may be intangible and others tangible, and they may be accompanied by facilitating goods.*** *This* sector has the highest growth rate in most economies of the world and 'has the largest single share of employment in the world GDP. It is said that in USA services account for over 70% of total income. In developing countries the share of services estimated is around 40% but with technological developments taking place it is likely to grow further. Information technology is already affecting the productivity of service production as well as increasing their transportability. In order to understand these changes better, we present a classification scheme. for services as, proposed by Baumol (and modified by Buffa and Sarin[5]) and classify services into the following four broad categories:

Stagnant Personal Services: These services require direct contact between the customer and the service provider. Since the quality of the service, to a great extent, depends upon the amount of time spent on services it 'is difficult to realise significant productivity gains in these services. For instance, hair cutting, teaching and counselling belong to this category. However, it is possible to realise significant gains in productivity in the supporting activities necessary for providing the service. For example, overhead projectors, photocopying facilities teaching aids, and computers hove all contributed to a higher productivity of teachers.

Substitutable Pelrsonal Services: These services also require direct personal contact but it is possible to substitute these services with technological alternatives. For example, guards can be substituted or helped by electronic security and serveillance equipment and domestic servants by a variety of household appliances like washing Machines, ovens, -mixers, etc. Information technology has played a big role in improving the productivity and the performance of this equipment substituting services. Centrally controlled computer devices or gadgets incorporating programming facilities have been developed to operate the domestic appliances in accordance with the consumers' needs or desires.

Progressive Services: These services require the use of some equipment and also direct personal contact with the receiver of the service. Technological change affects the productivity of the equipment more directly and significantly than the personnel

offering the personal contact-based service. For example, air transportation requires the use of the airplane as well as that of the ground and cabin crew, and broadcasting requires the use of studio and transmitting equipment as well as the "personal" contact established by the broadcaster(s). In a way, there is some hardware and some software required to render the service and information technology is affecting the productivity of the hardware more than that of the software.

Explosive Services: Services that do not require personal contact belong to this category such as telecommunications. Information technology is bringing about significant productivity increases in these services thereby reducing the unit cost and setting counter inflationary trends in prices. Developments in information technology are also contributing to the generation of new services in this category e.g., facsimile transmission (FAX), Videotext and Electronic Mail.

The above classification helped us to understand the role of information technology on productivity improvements in services. it also brought out another major effect of information technology, viz., its contribution to the transportability of services. Many services, based on exchange and transformation of information, are becoming more and more transportable. This can be seen happening in some banking and retailing operations, stock market services as well as in services relating to development of software.

Transportability of services has brought about at least three major effects in its wake. It has led to internationalization of services in many fields bringing out cross border flows of messages, information and data. Many of the services traditionally catering to local markets are now being offered to the global market. The second effect relates to changes in barriers to entry in services. In many services the barriers to entry are getting lower as the cost of entry is practically limited to the cost of equipment which itself is falling e.g., desktop publishing. On the other hand, the barriers to entry in some other services, where an integrated network of services is offered, are getting higher. This can be seen in some banking operations as well as development of software requiring satellite data transfers (since the cost involved in developing infrastructure is very high). Transportability of services has also increased the transparency of market due to widespread availability of information. The foreign exchange market and the money market have already affected by information technology. The Bombay Stock Exchange is being planned to be more transparent very soon. Being designated as National Stock Exchange, scripts of many international companies will be admitted and many Indian companies would be listed on the stock exchanges abroad.

Changes in Processes

information technology changes processes in two major ways: it allows the incorporation of higher levels of skills and functions into equipment (as in computer controlled machine tools and robots) and it increases the flexibility of many processes to achieve economies of scope involving almost continuous production of individualized products. This can be seen in Figure 3.7 below where different stages of manufacturing automation are plotted against volume and variety.

Process automation as the general characteristic of replacing direct labour (unskilled and semi-unskilled) with capital in conformity with the long-term shift in prices. Consequently, direct labour cost as a fraction of the product cost is declining. This phenomenon is wiping out the comparative advantage of developing countries in terms of low labour cost. Training and retraining of labour, including technicians / operators, has almost become a necessity in the existing enterprises.

The second effect is the combination of lower labour cost with higher automation. As can be seen from Table 3. I, automation seems to be removing the primary reasons for locating assembly operations in off-shore locations. This table compares the cost of assembling semi-conductor devices in the United States and Hong Kong with three alternative processes and the loss of comparative advantage for USA in terms of a lower labour cost in Hong Kong due to higher automation.

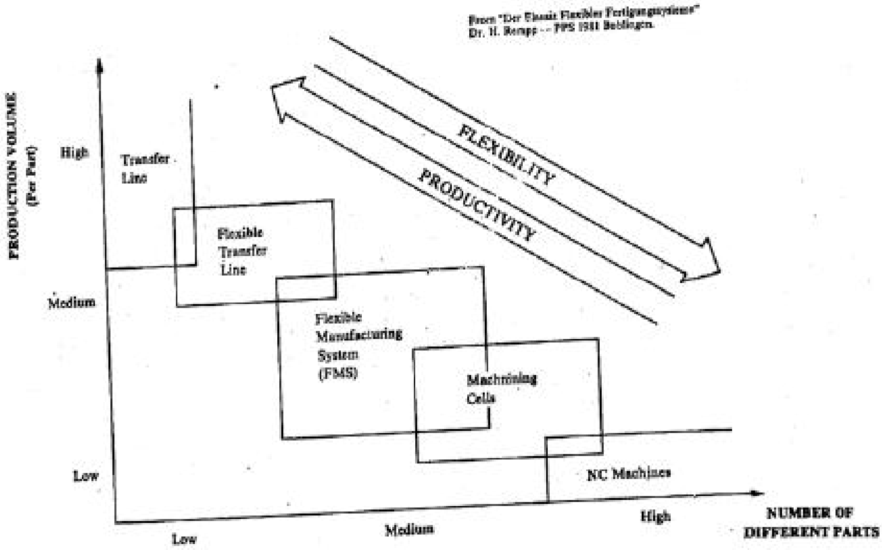


Figure 3.7 : Different Stages of Manufacturing Automation
Source : Arthur D. Little, The Strategic Benefits of Computer-Integrated Manufacturing, Cambridge, Mass.,-1983, p 19,

The automated assembly process using the so-called "hands-off" approach also produces products of very high quality. Information technology enables the producers of process equipment to develop horizontal links with other products or equipment or services such as material handling, integrated process control, fabricators etc. It also helps the manufacturing process through better planning, coordination and control. For example, modern manufacturing resource planning enables management to plan and control all manufacturing resources-material, equipment, personnel, tools, etc. more effectively, thus improving the productivity of operations as well as releasing investments in inventory.

It is now widely known that in Japanese enterprises inventories are operated on hourly basis, while in India and other developing countries inventories are still carried on monthly basis, which increases the over-all costs of operations and products.
These changes also affect the skill-mix of personnel required for the changed process. As production processes become more sophisticated, the number of direct

workers would perhaps show a decline whereas more engineers and technicians would be required to carry out reprogramming, installing, repairing and even developing newer processes. This would also call for extensive retraining at all levels, especially those skills, which are likely to become scarce.

Table 3.1 : Cost of assembling per semi-conductor device 1982 (US Dollars)

	Hong Kong	United States
Manual	.0248	.753
Semi-automatic	.0183	.293
Automatic	.0163	.0178

Source : *Global Electronics.Injbrtnation, 'Newsletter.* October 25, 1982.

Changes on Organisation

The changes in products, services and processes discussed above may, in many cases, require new forms of management structure and business organisation. This may be seen happening in many industries but perhaps not fast, enough, thus acting as a constraint in the institutionalization of other changes. The organisation structure can no more be static but should be capable of absorbing changes fast enough, at least in those organisations where• changes in products and processes are occurring very fast, so as not to constrain further changes. To be successful with new technologies, an organisation must be able to innovate and produce competitively. This shows up in the form of flatter organisations where the number of hierarchical levels gets reduced significantly. This also gives rise to higher dependence on task groups, expert ' committees and other forms of temporary working groups:

Information technology also allows higher integration of suppliers, vendors and subcontractors into the network of manufacturing companies. Specialist suppliers, in many cases, are better placed to adapt changes in products and processes and many large firms are finding it easier and more economical to "buy" than "make". In the case of many large manufacturers in developed countries, this has given rise to a hierarchical structure of subcontractors[6] akin to the organisation structure (with the 'subcontractors being part of the extended organisation). Ancillarisation of large manufacturing units in India is a step in this direction.

Increased office automation, has not only improved office productivity substantially but has also made the coordination functions easier and more effective as human resources can be used and consulted in real time.

3.5 MACRO EFFECTS OF TECHNOLOGICAL CHANGE

Having discussed the major impacts of information technology in the previous section, we would like to revert to technological changes in general andtheir effects on the economy, its competitiveness and its factor endowments. In the following paragraphs we would attempt to delineate the major consequences in terms of their macro effects.

Increasing Knowledge Intensity of Production

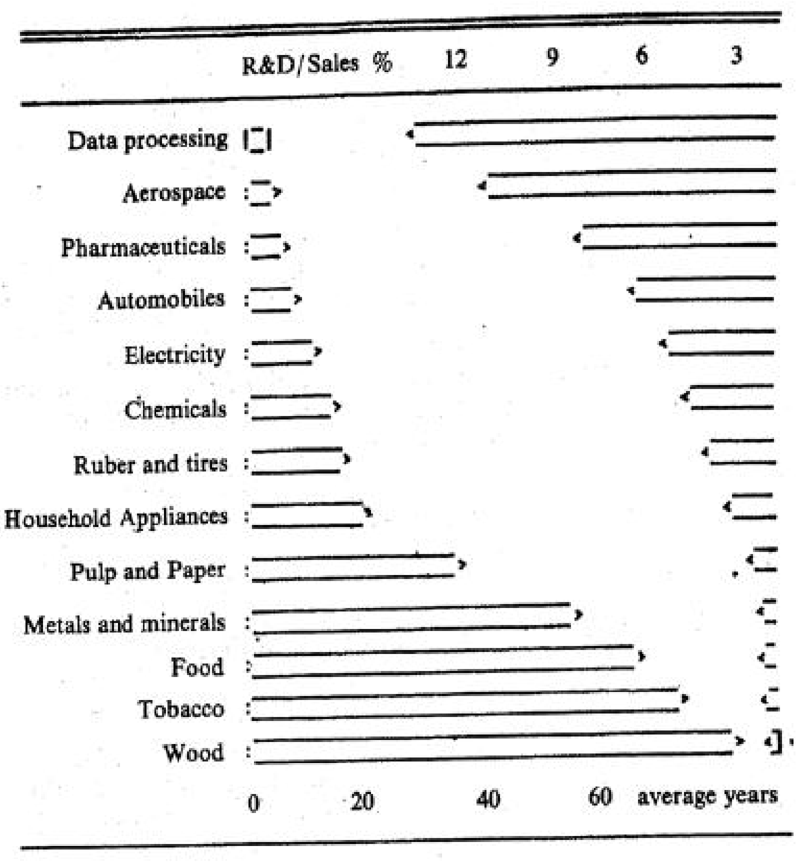
The growing importance of knowledge inputs in production is clearly visible in almost all industries. In fact, if we include in knowledge not only research and development (R&D) but also design, engineering, advertising, marketing and management, then knowledge input may have already become the primary factor of production displacing capital, labour and land in advanced industrial economies.

The radical innovations and innovating capabilities provide competitive advantages to commercial organisations. With access to global markets in most products and a growing number of services, the financial impact of a successful radical innovation becomes so important that firms end up spending higher amounts of money to develop further innovations. This can be seen from the large and growing number of scientists and engineers engaged in research and development activities in most industrialised countries, in many industries, the product life cycle is constantly getting shorter and firms have to spend more and more on R&D to remain at the cutting edge of technology and to exploit any breakthroughs achieved. Figure 3.8 shows the relationship between product life cycle and R&D costs as a percentage of sales in a few industries. High R&D costs increase the risks in knowledge generation (planned innovations). The competitive advantage together with access to global markets provides high returns to successful innovators.

Greater Mismatch of Skills

Technological changes have the general effect of replacing labour with capital. As capital equipment with newer technologies enters the production process it has two profound effects: (I) the employment level of personnel connected with the production and distribution of products comes down and (2) the skills required to work with the new generation of technology change.

In combination with other economic forces, the first effect continues to reduce the share of employment devoted to the production of goods, while expanding the service sector. The second effect changes the skill-mix of employment more abruptly as certain skills end up having practically no or little economic value. We have seen this happening with traditional skills like pottery making, horse-cart driving in India.



(a) product life cycle measured in average years

(b) R & D costs measured as a percentage of sales

Figure 3.8 : Product Life Cycle (a) and Research and Development Costs (b)

Source: Canadian Council of Professional Engineers, Brief on Research and Development in Canada (Ottawa : CCPE, February, 1983) p. 8.

What is now happening is that the knowledge intensity of the skilled worker (e.g., machinist) increases further with the introduction of newer equipment (e.g., CNC machine tools) and the new generation worker should have both machining and some programming skills. In many jobs, therefore, additional skills are demanded whereas in many others completely new skills are required.

Table 3.2 : Occupations with Largest and Fastest Projected Employment Growth, USA, 198495

Occupation	Employment growth (900s)	% Growth 1984-95
Largest Job Growth 1984-95		
	556	29.8
Registered Nurses	452	32 8
Janitors and Cleaners	443	15.1
Truck Drivers	428	17 2
Waiters and Waitresses	424	26.1
Wholesale Trade Sales Persons	369	29.6
Nursing Aides, Orderlies, etc	348	28.9
Sales Persons, Retail	343	12.6
Fastest Job Growth 1984-95	51	97.5
Paralegal Personnel		
Computer Programmers	245	71.7
Computer Systems Analysts (EDP)	212	68 7
Medical Assistants	79	62,0
Data Processing Eqpt. Repairers	28	56.2
Electrical & Electronic Engineers	206	52 8
Electrical & Electronic Technicians	202	50.7.
& Engineers	111	46.7
Computer Operators		

Source : *US Bureau of Labour Statistics,* Monthly Labour Review, November 1985.

The combination of the two effects is going to have profound effects on the pattern of employment. According to a study of the US Bureau of Labour Statistics, although occupations like computer programmers, computer system analysts, data processing equipment repairers and computer operators will be among the fastest growing occupations in US during 1984-95. More jobs in absolute numbers will be created in mundane occupations involving cashiers, nurses, cleaners, waiters etc. (refer to Table 3.2).

The wide disparity in the growth rate of employment in different occupations gives rise to scarcities and surpluses in different occupations. Even in India where the rate of technological change has been relatively low, a study conducted by the Department of Electronics (DOE) a couple of years ago, brought out the possibility of having a scarcity in occupations like computer progammers and system analysts. In all such situations, the emphasis on training (and retraining for those displaced) gets more pronounced. Unless this is effectively taken up, a growing mismatch between skills required and skills available in the economy could develop over a period of time.

Erosion of Competitive Advantage of Developing Countries

The developing countries have traditionally been having the competitive advantage of cheap and abundant labour and some natural resources. However, as described above in the previous sections, the labour component (unskilled and semi-skilled) in many manufacturing activities is falling, giving rise to an erosion of this important competitive advantage.

In the first phase of automation in the industrialised countries, it was hard automation that was being used. Specialised equipment was designed and used to produce large volumes of standardised parts. The labour required to run this equipment was relatively unskilled. Thus in the seventies, many manufacturers from the industrialised countries located their manufacturing units in some developing countries which offered them cheap labour and other infrastructural support. This movement of capital helped the developing countries very significantly in creating employment as well as registering industrial growth.

However, this trend was very short lived as the component of labour cost in the total manufacturing cost continued to fall. Further technological development ushered in soft automation giving benefits of automation even for smaller production lots using flexible manufacturing, giving ***economies of product mix*** rather than economies of scale. All of these developments have eroded the competitive advantage in having cheap labour and have arrested and in some cases reversed the movement of capital described earlier. In future also, availability of cheap labour may no longer be decisive in locating production facilities in developing countries, but skilled personnel still continue to be a factor to be reckoned with.

The technological changes of the last decade, especially the developments in information technology; materials and manufacturing, have created automated processes even for traditionally labour-intensive operations like assembly. As we have shown in Table 3.1 earlier, the newer automated assembly processes have "systematically eroded the comparative advantage in having cheaper labour. In many cases, the automated processes are preferred for better finish uniformity, higher quality and greater reliability; and hence developing countries going for the export market have to use these, thus affecting the potential employment in these countries.

The successive technological changes have, therefore, created difficult problems for the developing countries du to the erosion of their competitive advantage in many operations.

Activity 3

Mark-your response on a five-point scale as given below on each-of the following four aspects:

Pessimistic View	**Optimistic View**
Because of the speed of today's technological advances and the nature of new technology ,	Technology has been changing throughout history- past technological advances had lead to increase

is fundamentally different from previous technological advances— therefore, the past cannot be used to predict the future.	(1)—(2)—(3)—(4)—(5)	sed standards of living there is no reason why this trend should not continue.
Increased demand and consumption will in no way match the increased productivity gains realised through new technology. Therefore, massive unemployment will occur.	(1)—(2)—(3)—(4)—(5)	New technology will lead to increased productivity, resulting in higher wages and lower costs for goods. This in turn will increase demand and, thus, create more jobs.
New technology will lead to a greater split between high-skilled/high-wage and low-skilled/low-wage jobs (that is, an erosion of the middle class).	(1)—(2)—(3)—(4)—(5)	New technology will result in increased skills and higher wages for everyone.
Only top decision-makers will benefit from the fruits of new technology.	(1)—(2)—(3)—(4)—(5)	Everyone will benefit from the fruits of new technology.

3.6 SUMMARY

In this unit we have tried to take a look at technological changes, understand the meaning of technological change and analyse their effects. We found that production functions and, smooth isoquants which allow infinite alternative combinations **of** labour and capital are unable to describe technological changes adequately or realistically. A more realistic representation compels us to realise that production of a particular product requires a fixed amount of labour and capital and any change in this mix could be mainly due to technological changes. However, there are technological changes of various kinds such as incremental innovations, which are brought about by engineers and technicians mostly out of experience of working with the technology and some through radical innovations, which are generally the consequence of deliberate research and development efforts. Sometimes, a cluster of interconnected radical developments gets formed giving birth to a whole new industry. We called these as new technological systems. The fourth and the last category of technological change have been called technological revolutions, involving changes in techno-economic paradigms and having all-pervasive effects on almost all industries.

We next took a closer look at the information technology revolution currently sweeping our economies and its varied effects. We find that in many products new electronic processes and systems are replacing mechanical, eleotro-mechanical or electrical/electronic parts of a previous generation and even resulting in the creation of new products. With these changes, the value addition is getting transferred from the manufacture and assembly of conventional parts to tho manufacture of miniaturised components and systems. Product life cycles are getting shorter and products are getting linked to a larger system of compatible products. We also found that information technology has contributed to the rise in productivity of all services except perhaps stagnant personal services but even here the supporting activities have registered significant productivity gains in many cases. Information technology has increased the transportability of services creating global markets for some services. The changes in processes are widespread. Flexible manufacturing systems are shifting the focus from economies of scale to economies of scope or product mix and higher levels of skills and functions are getting incorporated in equipment designs. The fraction of labour (unskilled and semi-skilled) cost as a part of the total cost of production is coming down and the mix of skills required- for production is also undergoing a change. As a result to all the changes, organisation designs ate also becoming more dynamic and flexible, depending more on task groups and other temporary groupings.

In macro-effects-of technological changes we noticed three major patterns. The knowledge-intensity of production is increasing, and the mismatch between skills required and skills available is getting wider, calling for more extensive training and retraining. The competitive advantages of developing countries in terms of having cheap labour, and some natural resources, are getting eroded. The developing economies are therefore reorienting their policies to meet the changing environment by giving more emphasis to building their technological and other related capabilities.

Technological changes are induced by economic factors but they have not only economic but also social consequences. Industrial enterprises cannot remain insulated from these changes and therefore need to adopt appropriate corporate policies.

3.7 SELF-ASSESSMENT QUESTIONS

1) Use Production Functions to explain Incremental Innovations, Radical Innovations and New Technological,,stems. How would Technological Revolutions appear on these diagrams

2) It has been stated that, "the newer biotechnologies, although they certainly also have enormous growth potentia[1] have not yet reached the point where their macroeconomic impact could be great enough to carry the entire economy forward in the next decade or two" and so do not yet belong to our fourth category of technological change---viz. technological revolution. Do you agree with this statement? Please discuss.

3) Factor prices can induce technological change. However, Section 3.2 suggests that such technological changes are induced more by long-term movement of factor prices than by short-term fluctuations. Defend both these statements by commenting on Table 3.3 presented below. Keep in mind that the first oil shock was delivered, by OPEC in 1973 and the second one in 1979, whereas there were many brief periods after 1973 when the oil prices actually fell.

Table 3.3 : Energy and Economic Growth, IEA member countries, 1968483

					Annual Av. Change (%)		
	1968	1973	1978	1983	1968-73	1973-78	1978-83
Gross Domestic Product (GDP)[a]	3177	371.	4227	4595	3.2	2.6	1.7
Total Primary Energy Requirements (TPER)[b]	2586	3324	3592	3359	4.1	1.6	1.3
Total Final Consumption (TFC)[b]	1929	2491	2609	2398	4.2	0.9	1.7
TPER' GDP[c]	0.81	0.90	0.85	0.73	2.1	–1.1	3.0
TFC/GDP[c]	0.61	0.67	0.62	0.52	1.9	-1.5	3.5

[a]Billon US$, 1975 prices and exchange rates.

[b]Million tonnes of oil equivalent; total final consumption equals total primary energy requirement less transformation and distribution losses.

[c]Tonnes of oil equivalent per thousand US$.

Sources : Energy Policies and Programmes of IEA countries, 1983 Review, International Energy Agency, Paris, 1984; Energy Balances of OECD countries, 1960-74, OECD, Paris, 1970; Main Economic Indicators, OECD, Paris, various issues; W. Walker, Information Technology and the use of Energy, Energy Policy, October 1985; Quoted in C. Freeman and L. Soete, Factor Substitution and 'technical Change in C. Freeman and L. Soete *(eds.), Technical Change and Full Employment* (Oxford, U.K. Basis Blackwell Ltd., 1987).

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Uttar Pradesh
Rajarshi Tandon Open University

MBA-4.4
Technology Management

Block

2

TECHNOLOGY DEVELOPMENT AND ACQUISITION

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3LOCK 2 TECHNOLOGY DEVELOPMENT AND ACQUISITION

ı order to carry on its operations an organisation needs technology. This need can : met either through its own R&D efforts i.e., in-house generation or development f technology, or through acquisition from outside sources, located within or outside ıe country. A developing country may not have much stock of its own indigenous chnology. It may therefore have to acquire technology from foreign (developed) ountries. Service organisations, e.g., hospitals, canteens etc. often do not have their wn R&D and thus do not generate their own newer or better technologies. Such rganisations periodically acquire or upgrade their technologies from outside sources. lowever, large service organisations such as telecommunications and other utilities ın afford to generate their own newer technologies through R&D efforts.

or business enterprises generation of new technology through individual or ooperative R&D efforts is a must for survival and sustained growth in the present ay environment of global competition. An essential element of technology evelopment and acquisition is technology forecasting which is still in its infancy in ır country. However, this activity is likely to assume greater importance in the years › come. All these matters and issues are the theme of Block 2. This block has three nits.

nit 4 deals with **Technology Forecasting.** The unit begins by explaining the link etween technology forecast and technology innovation chain. The necessity and the le of technology forecasting is underscored. The various techniques of technological recasting are discussed; their relative merits and demerits and specific applications e described. Toward the end, some common mistakes and pitfalls in technological recasting are mentioned.

nit 5 focuses on **Generation and Development of Technology.** The process of :neration and development of technology is explained and its importance at the firm ıd national levels is highlighted. It is because of the importance of the generation ıd development of technology that it has to be made an essential component of a m's technology strategy. There are certain factors which affect the generation of chnology. These factors and their interrelationships are examined. The various proaches to development of technology at the enterprise level are discussed. The portance of R&D and the factors that lead to its fruition into commercialisation e stressed. Finally, how could a firm build an appropriate technology development frastructure is also explained.

nit 6 has its spotlight on **Technology Transfer.** It begins by explaining the various odels and modes of technology transfer. There is no gainsaying the fact that the m should have a technology search strategy which would enable it to identify or cognise commercially viable licensing opportunities, suited to its requirements. hat are the dimensions of technology transfer; what features a technology package n have; and what are the different routes of technology transfer are briefly plained. Before buying technology the buyer must have a close look at its own pacity to absorb any particular technology as also at the competence of the outside pplier. These are briefly discussed. The unit then shifts its focus to the modes of yment for technology purchased. Finally, what initiatives the governments in veloped countries generally take to encourage growth of technology, what kind of gulations generally exist in developing countries, and what is the Indian experience this respect are briefly dealt with.

UNIT 4 FORECASTING

Objectives

After studying this unit you will be able to:

- understand the definitions and concepts of Technology Forecasting
- understand the significance and role of Technology Forecasting in decision making at corporate level as well as national level
- know the classification and various methods of Technology Forecasting and their comparative advantages/disadvantages
- know about technology forecasting facilities in India.

Structure

4.1 INTRODUCTION

All that we know about the future is that it will be different from the present. Forecasting, that is, predicting what the future is going to be, is an essential element of any planning process, be it in our personal life, or in the public sphere. Forecasting for technology is no different in this respect. In this context the term `technology' should be understood in a broad perspective. It includes not only specifically "mechanical/physical hardware", but also encompasses associated "software" such as procedures and methods for organising human activity, and means for manipulating or engineering human behaviour.

Thus, technological forecast is a prediction of the future characteristics of useful machines, 'products, processes, procedures or techniques. There are two important points implied in this statement, viz.:

a) **A technological forecast deals with certain characteristics** such as levels of technical performance (e.g., technical specifications including energy efficiency, emission levels, speed, power, safety, temperature, etc.), rate of technological advances (introduction of paperless office, picture phone, new materials, costs, etc.). The forecaster need not state how these characteristics will be achieved. His forecast may even predict characteristics which are beyond the present means of performing some of these functions. However, it is not within his scope to suggest how these limitations will be overcome.

b) **Technological forecasting also deals with useful machines, procedures, or techniques.** In particular, this is intended to exclude from the domain of technological forecasting those items intended for pleasure or amusement since they depend more on personal fads, foibles or tastes rather than on technological capability. Such items do not seem to be capable of rational prediction and thus the technology forecaster generally does not concern himself/herself with them.

Anticipating technological change is an important management function. One must do so to plan new products and new businesses. One must also avoid being technologically blind-sided by competitors with technologically superior products. Yet this is not easy to do because often technological progress cannot be anticipated. However, it can also. be planned. Technological forecasting tries to put as much planning as is possible into technological change. Incremental innovations have often been planned or, at least, sought after. The seeking of or anticipation of technological innovation has been called "technology forecasting".

Technological forecasting, in the formal sense, has not been widely practised in our country, as it has been used elsewhere, more especially, in industrially developed market economies. This is because commercial success in such economies is dependent, to a large extent, on the ability of a firm or an organisation to identify emerging/future technologies well ahead of time so that appropriate decisions or advance action could be taken to meet/deal with the likely challenges of the future. Recognising the importance of forecasting in the technological planning process, the Government of India has established a Technology Information Forecasting and Assessment Council (TIFAC) under the Ministry of Science & Technology, to promote action oriented studies and forecasting in selected areas.

4.2 TECHNOLOGY FORECAST AND TECHNOLOGY INNOVATION CHAIN

We have discussed "innovation" in some length in Units 1 and 2. However, to understand the ramifications of technological forecasting in its entirety, we need to further understand the *various stages of technological innovation.* The forecaster must state clearly the stage for which he is forecasting. For instance, when he makes use of historical data on a number of devices, he must be clear about the stage of innovation represented by each of his data points. Mixing of data representing several stages may lead to errors and confusion. Selecting past data consistently, so that all points represent a single stage of innovation, is thus very important. Since innovation is usually a continuous process, breaking it or subdividing it into various stages, is done for the convenience of the forecaster. The essential point for you to understand is that the stages chosen on the continuum of progress must be capable of unambiguous definition, so that there is no mixing up of the data and there is no occasion to raise a question whether an innovation has reached a certain stage or not. Generally, one may use the following stages to describe the progress of an innovation throughout its life, from beginning till end :

a) Basic scientific findings/discovery of a principle
b) Laboratory or bench level feasibility
c) Operating prototype/pilot plant
d) Commercial introduction or operational use
e) Widespread adoption
f) Diffusion to other areas
g) Social and economic impact

Each of these stages has a specific role to play and 'contribute to the innovation of a technology. Briefly, they are described as under :

a) **Basic Scientific findings/discovery :** This establishes the minimum knowledge base on the basis of sound scientific principles from which a solution to a specific problem could be found.

b) **Laboratory or bench level feasibility :** At this stage, depending on the identified problem, a laboratory workable model could be fabricated without violating any natural or physical laws. This would generally be able to work in the desired way only in the laboratory environment, under controlled conditions and supervision of trained scientists, technologists or technicians.

c) **Operating Prototype/Pilot plant :** On reaching this stage, it would be possible to obtain design/engineering parameters to construct a device/system which would be capable of working in an operational environment using commercially available inputs.

d) **Commercial introduction or operational use :** This stage represents not only technical and design adequacy, but also economic feasibility. Generally, the first production model is the benchmark of completion of this stage.

e) **Widespread adoption :** At this stage **having** demonstrated the technical and/or economic and/or environmental superiority, the technology is now poised to supersede. and replace the prior devices, procedures etc. on a wide scale.

f) **Diffusion to other areas :** At this stage, the new technology not only replaces the old one, but is also adopted to perform such functions as were not being performed by the earlier., devices and techniques.

g) **Social and economic impact :** At this stage, the innovation will affect the behaviour of the society and its use may reach a point where its impact will be felt on the economy.

Every innovation does not go through all these stages. Some may reach a particular stage and go no further. In other cases, two or more stages may be combined. For instance, there may be innovations where the first production model also serves as a prototype. This practice of combining or telescoping stages of innovation is fraught with danger. There are many instances where the first production or operational model of some innovation contained serious flaws which could have been discovered while testing the prototype had it been done separately. Once the production design is fixed, the defects/shortcomings cannot be eliminated at reasonable cost and the device may be unacceptable as it is.

Finally, it must not be assumed that all innovations are based on scientific findings, Most of the innovations have a certain degree of empirical content, and many, especially in the past, have been based on sheer empiricism. Hence it is quite possible that a device might not pass through the first stage of our list of stages of innovation, but might start at the second or even the third stage. However,. it may be pointed out that the practice of skipping any stage in general increases the risk of failure. Nonetheless, there are many illustrations of innovations which have successfully skipped one or more of the early stages, more specially these days, when mathematical modelling is used to simulate the operation of a prototype/pilot plant.

With the use of the concept of stages of innovation, it is possible to question more precisely just what is meant by a particular technological forecast. One can ask whether the forecast is stating that a certain capability will be technically feasible or whether it will be commercially successful or whether it will be superior to all other approaches to performing the same function, etc. It is important that a forecast concerning one stage is not misinterpreted to apply to a later stage. A forecast of technical feasibility, for instance, must not be confused with a forecast of commercial success. The former does not always imply the latter.

We suggest that you familiarise yourself with these concepts by referring to literature and read widely to match your practical experience.

Having briefly discussed the preliminaries of technology forecasting and technology innovation chain, we now turn our attention to why technology forecasting is necessary.

4.3 NECESSITY OF TECHNOLOGY FORECASTING

Historically, the U.S. Navy was one of the major institutions which started formal technological forecasting to support the preparation of a fifteen year plan to identify the likely opportunities and threats, and to develop a technological setting for the future. Technology forecasting has now assumed importance in India due to the structural reforms introduced in our economic system with a view to creating a market driven economy. Essentially, technology forecasting is used for the purpose of :

a) scanning the technological environment,
b) anticipating emerging technological changes,
c) identifying suitable technologies by evaluating, various alternatives,
d) planning for technologies for future needs.

We can identify four elements of a forecast which can be specified and/or estimated. These are (a) the time period, (b) the nature of technology, (c) the characteristics to be exhibited by the technology, and (d) the probability associated with the characteristics. The time period may be stated generally, or it may be. given precisely. The technology being forecast may be narrowly defined, or it may encompass a very broad range. The characteristics may be stated only in general terms, or may be given precise quantitative values. The probability associated with the characteristics may be given only generally, as high or low, or it may be stated in precise quantitative terms. And for each of these elements of the forecast, the degree of precision may vary anywhere between the two endpoints of generality and precision. The precision associated with each element of a forecast should be determined by the use to which the forecast will be put. The forecast should thus be tailored to the decision making situation, and the precision associated with each of the elements should be appropriate to this situation.

Martino has shown that there is really no alternative to forecasting. He considered various possible alternative scenarios like (a) regimes of no forecast (tacitly assuming there would be no change in the environs in future), (b) future is a total gamble and it could be met without any anticipation, (c) resting on laurels of the glorious past presuming that it would bring a glorious future, (d) dependence on limited forecasting without taking into consideration all round changes in the environs, and (e) taking crisis action to meet the situation. All of these, he showed, may spell disaster for a firm or an organization.

On the other hand if a decision maker has several alternatives open to him, he will choose the one which provides him with the most desirable outcome. Thus, his decision is invariably based on a forecast. The decision maker does not have a choice as to whether or not he will make use of a forecast; his only choice is whether the forecast is obtained by rational and explicit methods or by intuitive means. The virtue of the use of rational methods is that they are teachable and learnable; they can be described and explained. They provide a procedure which can be followed by anyone who has been able to undergo the necessary training. In some cases, in fact, the methods are even guaranteed to produce the same forecast regardless of who makes it. The virtue of the use of explicit methods is that they can be reviewed by others. In particular, the forecast can be reviewed by several people prior to its acceptance by the decision maker.

All these discussions basically highlight one very important aspect that we are dealing with a probabilistic situation and we should gear ourselves to meet it with a certain degree of confidence and with all elements of surprise anticipated. A logical question that 'follows is: How good is the forecast? Will it come true?

To answer these questions, let us classify situations according to the degree of control the decision maker can exercise. There may be three types of situations:

a) Absolutely no control
b) Partial control
c) Full control

We would attempt to analyse the efficacy of forecasting in these situations.

a) **Absolutely no control :** Consider a commuter seeking a forecast of the commercial availability of a solar-powered car, say by the year 2000. While he might seek the forecast out of simple curiosity, more likely he wants to make plans for some activity which will be affected by this forecast, say whether to buy a petrol-driven car or not. Naturally, he wants to plan correctly, for if he bases his plans on a forecast of a solar car becoming available and it does not materialise, the forecast has been useless to him or, worse, it has misled him into foregoing his. buying a petrol-car. It appears, then, that such a forecast has to be correct to' be useful. When a decision maker has absolutely no control over the outcome of a particular situation (that is, when none of the actions open to him can alter the outcome), he wants to tailor his actions to the eventual outcome. He wants to maximize the benefits from a favourable, or minimize the impacts of an unfavourable outcome. In this situation, if the forecast does not come true, it is of no utility to him.
b) **Partial Control :** Most day-to-day decisions fall in the area of partial control over the. outcome. The decision maker is interested in influencing the outcome of a situation in a way as favourable as possible to him, If he is presented with a forecast which he considers desirable, he will exert such control as he possesses to ensure that the forecast is realized, thus influencing either the reliability or the time frame of the forecast, Likewise, if he is presented with a forecast he considers undesirable, he will exert his control to forestall it. Thus, there will be a certain element of self-fulfilment or "self-defeat in the outcome of the forecast.
c) **Full control :** At the other extreme, when the decision maker has complete control over the outcome, he does not even need a forecast. The outcome will be what he wants it to be. Someone else may perhaps find a forecast of his decision useful, but he himself does not need a forecast of what he is going to do.

This means that the goodness of a forecast cannot be measured in terms of whether it came true. Suppose that a decision maker is presented with a forecast of an undesirable outcome. As a result of the forecast, he acts to forestall the undesirable outcome, and is successful in doing so. He thereby negates the forecast. But can it be said that the forecast was wrong and, therefore, worthless? On the contrary, it must be recognized that it was highly useful to the decision maker. Had it not been made, he might not have acted as he did, and would, therefore, have been faced with an undesirable outcome. The same situation can arise where the decision maker acts to achieve a favourable outcome on the basis of a forecast that such an outcome is possible. This forecast was useful, not because it automatically came out true, but because it caused the decision maker to take appropriate action. At the moment, however, we will only note that **the measure of the value of a forecast is not its validity, in terms of whether or not it comes out true, but its utility in helping the decision maker make a correct and timely decision.**

It is essential to recognise that a forecast does not put anything into the future. Instead, it tells only of the implications of available information about the past. These implications are 'connected with the future through a logical framework. Hence, the utility of a forecast for decision making purposes depends on the validity of the logical framework it uses and the extent to which it extracts all the implications which are contained in the body of available information. This ability to evaluate the utility of rational and explicit forecasts is, of course, one more reason to prefer this type of forecast. However, it may be emphasised that following a certain procedure may not guarantee the forecaster against error; it may only reduce the likelihood of error. Hence, the forecaster is never absolutely certain that he has prepared the most useful possible forecast with the available data he has and the resources he has employed.

Activity 1

Arrange a meeting with .an experienced and knowledgeable executive of the Engineering and Technology ((r similar) Division of the organisation with which waat are associated. Gather the following information and discuss with him

i) Do they have any plans to acquire new technology?

…………………………………………………………………………………………
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Did they attempt to make any'forecaaste at any stage or gather information about impending technologies related to their organisation? With what other organisations they collaborated and from what sources they obtained inform :Mon regarding forecasted technologies?

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4.4 ROLE OF TECHNOLOGY FORECASTING

The forecast serves as an input to the process of making plans and decisions. Martino has described the role of the forecast in planning as follows :

a) The forecast identifies limits beyond which it is not possible to go,
b) It establishes feasible rates of progress, so that the plan can be made to take full advantage of such rates; conversely it does not demand an impossible rate of progress,
c) It describes the alternatives which are open and can be chosen from,
d) It indicates possibilities which might be achieved, if desired,
e) It provides a reference standard for the plan. The plan can thus be compared with the forecast at any point in time, to determine whether it can still be fulfilled, or whether, because of changes in the forecast, it has to be changed, and
f) It furnishes warning signals, which can alert the decision maker that it will not be possible to continue present activities.

If the forecast makes a decision maker aware of alternatives which he might not have discovered otherwise, it has increased his degree of freedom. The important point is that the purpose of the forecast is to improve the quality of his decisions and not to force him to accept a particular decision.

4.5 CLASSIFICATION OF TECHNOLOGY FORECASTING APPROACHES

There are two approaches to technology forecasting namely

a) Exploratory, and
b) Normative.

Exploratory forecasting, in a way, transcends into the future from the past performance or experience. Its techniques deal with the analysis of the technological capability, features etc. of the past, evaluation of the present, looking forward to the future, taking into account the dynamic progression which brought us to today's position.

Unlike exploratory forecasting, normative approach begins from the future and works out desired landmarks backwards to the present state. In other words, the mind is projected into the future by postulating a desired or possible state of technological development to satisfy a specific need. The forecaster then works backwards to identify the steps or landmarks necessary to be achieved, with assessed level of probability, in order to reach the end point or goal set hence fore.

However, it must be appreciated that exploratory and normative methods are not competitive nor do they substitute for one another. Essentially they are complementary to each other and have to be used together. Usually one does not attempt to prepare an exploratory forecast of some technology unless there is a normative forecast that the specific technology will be needed. Similarly, no one will generally prepare a normative forecast without some preliminary idea that it may be possible to meet the desired objective.

4.6 METHODOLOGIES OF FORECASTING CLASSIFICATION

Different techniques, as shown in Figure 4.1 have been developed over the years to deal with forecasting methodologies. The forecaster has to judiciously select a technique or a combination of techniques depending upon the methodology and end objective in view. The common techniques could be summarised as follows:

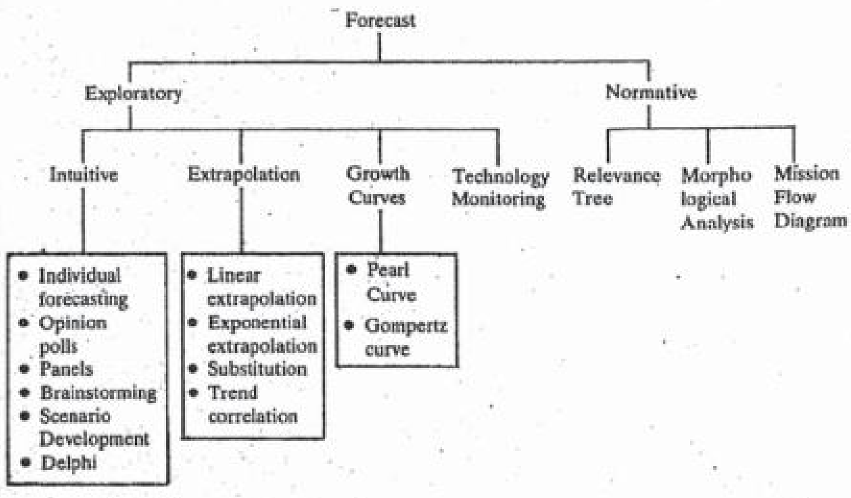

Figure 4.1 : Forcasting Methods and Techniques

We shall endeavour to describe briefly some of the corilmonly used techniques; however, you may refer to literature to get a grasp of the other higher level forecasting techniques. But before doing so, we list in Table 4.1 the Technological Forecasting (TF) methods used for each of the four main activities in the business environment.

Table 4.1 : Business Activity and TF Techniques

	Business Activity	TF Techniques
i)	Searching for relevant scenario	• Expert opinion • Panels • Brainstorming • Delphi • Technology monitoring • Scenario development
ii)	Searching for trends among parameters	• Extrapolation • Growth curves • Substitution
iii)	Searching for alternatives among various choices to reach a goal	• Relevance Tree • Morphology • Cross impact analysis • Dynamic modelling & simulation
iv)	Identifying implications for action	• Expert consultation • Scenario building • Modelling & Simulation

Use of a combination of methods will generally be more reliable than dependence on a single parameter or single forecasting method. Also, it may be useful to have the user of a technology, generator of a technology, manufacturers, suppliers and designers involved in an integrated exercise to shape the combined perspective into a forecast.

4.7 TECHNOLOGICAL FORECASTING METHODS

Some of the TF methods are now elaborated in this section.

i) Brainstorming

The oldest method of forecasting is probably brainstorming. It is conducted by a group of people' who attempt to forecast about a specific technology by collecting/contributing all the ideas spontaneously. The basis of the method is that ideas should not be evaluated at the generation stage during which many new ideas emerge. Thus, there is a separation of the idea generation and the evaluation stages. The reason for this is that new ideas can emanate even from people who do not have a thorough expertise in a given field. The major objective of brainstorming is to stimulate the generation of ideas on a given technology. It does not matter even if they are wild, highly impractical or exotic. Ideas are formed/offered spontaneously in a relatively unstructured environment. After they have been presented, they are analysed and evaluation is carried out in depth.

Steps involved in brainstorming

Step 1 : Identification of a person as the group leader. It is not necessary that he is chosen by his age or his position or seniority or expertise in the technology, but he must have the requisite experience of integrating or channeling the ideas to lead to a solution.

Step 2 : Identification of the problem by a group so that the multiple dimensions of the problem involved are clearly highlighted:

Step 3 : Definition and redefinition of the problem so that it is unambiguously understood by the group. Possible solutions are deliberately avoided.

Step 4 : Idea generation process is initiated. Once a number of ideas are collected, a number of triggering questions are initiated to help combine ideas or approaches:

Step 5 : The recorded ideas are reviewed, classified and streamlined into related ideas and clusters.

Step 6 : Rearranged ideas are evaluated, possibly through reverse brainstorming i.e. through a series of eliminating questions. Least favoured ideas are rejected. Preferred ones are analysed and forecasts are prepared in consultation with other functional experts.

The structure of the problem solving group is a major factor which determines the goodness of the forecast. A group, to be effective, has to have a variety of people, such as :

a) users of technology
b) experts, knowledgeable in technology
c) experts, knowledgeable about market
d) economists/financial analysts
e) dreamers with new ideas
f) persuaders who can help acceptance of an idea technology forecasters
g) consultants

Based on experience, it has been found that the session could be structured, to some, extent, to facilitate solution of the problem during brainstorming. This, in a way, involves first establishing a method for obtaining a variety of emergent ideas and then converging it on to the given solution.

Applications

Brainstorming has been applied to a wide range of R&D, technological and business problem solving. This method has been used for following purposes, namely:

a) for obtaining new ideas of products/process/services/procedures
b) for identifying new uses or market segments
c) for overcoming bottlenecks
d) for identifying alternative options or methods

The group can have five to ten members. If there are more than about 10 members, processing of the proposed ideas becomes difficult. In some cases outsiders are used as leaders.

Advantages and Disadvantages

The advantage of brainstorming is that it is easy to organize and the resources needed are modest. But it requires an experienced person to conduct it. A number of sessions may be necessary since at the initial stages participants may be somewhat skeptical or hesitant. Sufficient time is needed for organizing a brainstorming exercise.
Further, considerable preparation has to be made before the actual exercise begins.

ii) Delphi Technique

An objective forecast should have a sound logical framework to ensure its repeatability. Formal forecasting techniques are used to replace subjective opinion with objective data using a replicable method. Even though objective technique's are desirable, there are three situations in which expert opinion (subjective or intuitive method) may be resorted to

i) when there is no historical data, especially situations in which new technologies are involved; expert opinion is the only possible source for a forecast,
ii) when impact of external factors is more important than the factors that governed the previous development of the technology. Under this condition, forecast using past data is irrelevant,

iii) when ethical considerations rather than technical and economic considerations govern the development of a technology.

Under such conditions a Committee approach is normally resorted to. The Committee approach has the following advantages and disadvantages.

a) Advantages

i) The sum total of the information available to a group is at least as great as that available to any one individual.

ii) Committee can bring in interactive aspects which a single member cannot contribute.

b) Disadvantages

i) Minority views are normally neglected if, either the group is highly bureaucratic or, consists of individuals from diverse disciplines.

ii) In a group the tendency is to agree with the majority even when the individual feels that the majority is wrong.

iii) A group has its own way of functioning i.e. it has its own internal dynamics. Reaching an acceptable goal becomes an end in itself. Group members may have vested interests in certain outcomes or a common bias and this can affect the results.

To overcome the disadvantages of the Committee approach and to make use of the advantages inherent in the committee, a method known as Delphi has been developed.

Delphi is a 'programmed, sequential questionnaire' approach. (The word has its origin in 'Oracle of Delphi' in which a group of learned persons used to make forecasts.) Instead of an individual making a forecast, a group prepares a forecast but with certain characteristics; (a) anonymity, (b) iteration with controlled feedback and (c) statistical group response taking into consideration minority views. The detailed steps involved in a Delphi exercise are as follows:

Step 1: Identify the specific area or field in which a Delphi exercise has to be carried out.

Step 2 : Identify a set of users, technology generators/experts, equipment manufacturers, development bankers, and social scientists and others who can help in preparing a set of questions for forecasting technological developments in the given area.

Step 3 : A small core group is formed to prepare the questionnaire with the help of persons at (2) to cover among other aspects the desirability of the technological development. its feasibility, time frame and resources needed for commercial use, and impact. Background data may be included to reduce subjectivity.

Step 4 : The questionnaire is then administered to a number of participants to cover a wide cross-section of interests.

Step 5 : The first round responses for the questionnaire is obtained and processed, wherein minority and even extreme views etc. are also included.

Step 6 : The second round questionnaire, containing the processed responses of the first round questionnaire, is sent back to the participants to give their revised comments.

Step 7 : The second round results are then processed to get the consensus results.

Thus Delphi provides a consensus view based on the opinion of a large number of participants and can be considered as a way of combining/integrating forecasts.

Application

The Delphi method is used to :

a) identify new factors likely to influence the future state of technological development,
b) obtain probabilistic estimates of technological performance over a specified time horizon,
c) obtain forecasts of a time scale for an event where other methods. cannot be used,
d) ascertain the feasibility of a given event occurring under specified conditions,
e) obtain subjective quantitative measures of technological performance in the absence of objective data.

The preparation of the questionnaire has to be done very carefully and should, among other conditions, ensure that:

a) The issues are unambiguously specified
b) The questions are unconditional and not interlinked to conditionality specified elsewhere
c) The definition of probability for occurrence of an event etc., sought in a question should be clearly defined/explained.

Advantages

Delphi is a useful technique for (a) obtaining forecasts when there is a limited amount of historical data, and (b) for fields which are highly interactive and interdisciplinary involving diverse parameters such as social, technical, economic, political and managerial.

Disadvantages

a) It does not have any 'logic' underlying each prediction and if repeated, it may not give reproducible results; and
b) Although it may produce a high degree of convergence, yet this convergence does not imply a high degree of reliability:

iii) Trend Extrapolation

This is one of the simplest and most commonly used forecasting techniques. This method uses historical data on selected technological parameters for projecting the future trends. It thus implies that the historical trends are a resultant of a number of forces which will continue to behave as in the past unless there are strong reasons to the contrary. A single function or an attribute of a technological performance or a technical characteristic is used for projection into the future. It is generally assumed that it is possible to quantify the changes in the performance of a technology based on either a straight line trend extrapolation or an exponential trend extrapolation on continuation of past attributes. If there has been some regular rate of change in the , past of functional capability, it is quite likely that the rate of progression will continue at least in the near future.

However, there are two instances where trend extrapolation treatment should not be pursued, namely :

a) in cases where there are known natural limits such as 100% efficiency achievement in a steam engine or for that matter any conversion of energy, and

b) cases where it is known that conditions governing a specific trend in the past have changed.

With these brief introductory remarks, let us consider how the techniques of trend extrapolation could be made use of in practice.

Linear Trend Extrapolation

Straight line extrapolation method uses projection of a parameter assuming a linear growth trend.

The linear trend could be represented by

$y_i = \alpha x_i + \beta$, where

y_i = Value of parameter estimated in the i^{th} year.

x_i = Value of the i^{th} year, a and (3 are constants to be estimated.

α and β could be estimated by the method of sum of squares and minimising them from the projected trend extrapolation. Therefore, sum of squares, S (a,(3) are obtained by

$$S(\alpha,\beta) = \sum_{i=1}^{n} \{y_i - (\alpha x_i + \beta)\}^2$$

where n = number of observations.

On minimising the estimates of, α and β, we get

$$\frac{\partial S}{\partial \alpha} = \sum_{i=1}^{n} 2\{y_i - (\alpha x_i + \beta)\}(-x_i) = 0 \qquad \text{......... 1}$$

$$\text{and } \frac{\partial S}{\partial \beta} = (-)\sum_{i=1}^{n} 2(y_i - \overline{\alpha x_i + \beta}) = 0 \qquad \text{......... 2}$$

Which give ride to two normal equations:

$$\alpha \sum_{i=1}^{n} x_i^2 + \beta \sum_{i=1}^{n} x_i = \sum_{i=1}^{n} x_i y_i \qquad \text{......... 3}$$

$$\text{and } \alpha \sum_{i=1}^{n} x_i + n\beta = \sum_{i=1}^{n} y_i \qquad \text{......... 4}$$

Solving the equations 3 and 4 simultaneously we obtain

$$\alpha = \frac{n \sum_{i=1}^{n} x_i y_i - \left(\sum_{i=1}^{n} y_i\right)\left(\sum_{i=1}^{n} x_i\right)}{n \sum_{i=1}^{n} x_i^2 - \left(\sum_{i=1}^{n} x_i\right)^2}$$

and $\beta = \bar{y} - \alpha\bar{x}$, where $\bar{y} = \frac{1}{n}\sum_{i=1}^{n} y_i$ and $\bar{x} = \frac{1}{n}\sum_{i=1}^{n} x_i$ are arithmetic averages.

Extrapolation using Exponential Trend

It has been found by empirical study that many technologies do grow exponentially though there is no sound theoretical basis for it. When the exact behaviour of a technology is unknown and there is no reason to suspect departure from an exponential growth, the forecaster may be justified empirically to assume that the technology in question would grow exponentially. The extrapolation using exponential trend is thus suitable to deal with the growth of particular technological capability, or production trends etc. when they are plotted against time. A linear regression of the logarithm of the parameter against time, or alternatively, a straight line on a semi-log plot, is equivalent to exponential growth of functional capability.

The exponential growth curve could be assumed to be
$y_i = ab^{x_i}$, where

y_i Value of parameter to be estimated
x_i = Value of the i^{th} year a, b are constants to be estimated.

Taking logarithm on both sides,

$\ln y_i = \ln a + x_i \ln b$

$= A + B\ x_i$, where $A = \ln a$ $B = \ln b$

which is a straight line.

Now, applying the sum of squares method and minimising it, as before, we get two normal equations, viz :

$$\sum_{i=1}^{n} \ln y_i = nA + B \sum_{i=1}^{n} x_i \qquad \text{.......... 1}$$

and $$\sum_{i=1}^{n} x_i \ln y_i = A \sum_{i=1}^{n} x_i + B \sum_{i=1}^{n} x_i^2 \qquad \text{.......... 2}$$

We can easily solve these two equations from a set of observed data and find the estimates of A and B; and from those the estimates of 'a' and 'b'.

A word of caution is necessary here for pursuing the exercise of curve fitting for trend extrapolation. You may realise that some of the trends will not follow a straight line pattern or an exponential pattern to describe the trend and its underlying direction. In such cases a parabolic trend [$y = as + a_1x + a_2x^2$] or a polynomial trend [$y = ao + aix + a_2x^2 .... a_t, x^p$] may be applied to identify the underlying trend. Regression analysis can be performed by general method described earlier by finding out the normal equations by minimising the sum of squares. You are advised to work out the normal equations by yourself as an exercise.

Applications

Extrapolation of past data can be used for predicting future trends and thus finds application in- predicting future performance characteristics of a technology, production level of an item/product or for that matter any parameter that is amenable to such treatment. The crucial aspect of this methodology is identification of an appropriate index/parameter.

In general the trend projection method consists of the following steps :

Step 1: selecting an appropriate parameter to describe the attribute of interest to the forecaster,

Step 2 : collecting past data of this parameter fora reasonable period,

Step 3 : plotting the data graphically to determine if straightline/exponential/parabolic etc. can best describe the trend, .

Step 4 : fitting an appropriate curve as described earlier and using the mathematical equation to project events in the near future.

Trend extrapolation has been used extensively for forecasting technological as well as non technological parameters. Routine and mechanical use of this technique has been responsible for many of the serious forecasting errors, since extrapolations cannot predict the trend if underlying causes are drastically changed at a point of time. Extrapolation can be used only for short range forecasting.

Advantages and Disadvantages

Trend extrapolation is an objective technique and does not use any intuition for its application. The method is teachable/learnable, reviewable and reproducible by others. It is simple to use and quick to interpret, but extrapolation cannot be used unless there is sufficient past data. Although one can proceed into the future for as many years as are equal to the number of years of past data, it is however, prudent to confine the prediction to only short time intervals considering that the present day product/technological time cycles have greatly shortened over the years.

iv) Technology Monitoring

Technology is fast changing. If one has to reduce uncertainty, there has to be a system for monitoring the signals of technological change, followed by analysis of the meaning of signals of change. Forecasts based on trend or growth curves assume that there is a fairly good continuity between the past and future. Hence, these methods are inherently incapable of predicting breakthroughs. Technology monitoring is one of the techniques, which can be used for monitoring breakthroughs through precursor events. Most large manufacturing and trading organizations abroad have formed systems for continuously scanning the technological environment, variously known as technology scanning/monitoring/intelligence etc.

A forecaster has thus to become aware of the diverse events, as they occur, that have a bearing on the technological area, determine their possible significance, ensure they are not forgotten with the passage of time, and relate them to future events as they occur and assess their combined significance. In large organisations where several technological fields are to be monitored, scanning has to be carried out by a 'team consisting of people from various disciplines.

Monitoring process consists of the following steps:

Step 1 : Information scanning

Step 2 : Screening the scanned information

Step 3 : Evaluation of the screened information and development of ideas.

Step 4 : Utilization of the evaluated ideas for R&D planning, project formulations, product diversification, etc.

Information Scanning

There is no specified methodology for technology scanning; the general principle is to have access to as much relevant information as the resources permit not only from primary sources like journals/patents documents etc. but also from commercial data exchanges/sources etc.

However, the aim is to get data or information related to the technological field on the following aspects :

i) competitor's R&D plans, approach/ideas, manufacturing programme, marketing thrust/share, financial health etc.
ii) Environment/health of the industry/sector
iii) Government's .policies, incentives/disincentives, regulation/control
iv) Manpower capabilities: educational/skills development, R&D etc.
v) Social attitudes/preferences/prejudices.
vi) Demand and supply estimates

Scanning has to be comprehensive to be useful and it has to be done on a regular basis. The scanned information is stored after coding, preferably indicating the source of the information.

Screening of the scanned information

Volumes of information stored may not be of much use to the organisation unless they are properly screened and subjected to further evaluation. It is, therefore, essential that the information of relevance be identified, according to short and long-term objectives of-the organisation, for detailed scrutiny and evaluation.

Evaluation of the screened information and development of ideas

At this stage, the forecaster or the group of forecasters will subject the relevant information to detailed scrutiny and evaluate them in-house or even in consultation with external experts as to their usefulness to trigger newer activities in the organisation. In other words, the forecaster would be in a position, depending on the trend/signal identified on a specific technological field, to advise the decision maker to embark on new plans for initiating appropriate action in areas like R&D/production/marketing/diversification..of product range etc.

Utilisation of evaluated ideas

The decision maker would now be in a position to dovetail all relevant inputs i.e. technological forecast, Government policies, financial commitments, business environs etc. in order to make up his mind as to whether particular course of action could be pursued or not.

Applications

Technology monitoring is a useful tool for anticipating changes through continuously monitoring the signals of change, especially for the following:

a) to plan R&D
b) to obtain new ideas on products/process/technology
c) to identify areas for corporate diversification/investment/collaboration
d) to identify possible sources for technology acquisition/licensing etc.

Advantages and Disadvantages

The advantage of this method is that it can be an efficient early warning device on threats to existing products/process/services; or may provide signals on opportunities for new products, processes or services. It is a useful technique for senior level management and decision makers. The disadvantage of the method is that it is very cumbersome. To enable it to be useful a team is needed for carrying out the monitoring work and at least two years of basic data collection as well as storage is necessary. The database has to be multidisciplinary and fairly large. Lastly, all these may be possible only in the case of comparatively large corporations or industry associations or government. Comprehensive monitoring systems are expensive and need substantial resources for their regular operation.

v) Growth Curves

It has been observed that the growth pattern of many of the biological systems follow an 'S' shape curve. Initially the growth is slow, and then the growth rate increases and finally levels off into the natural limit. Fruits, vegetables, population of yeast cells etc. show an S shaped growth pattern in natural environment (Please refer to Figure 4.2 in the unit).

Scientists/researchers, in their continuous endeavour to evolve improved and realistic techniques of forecasting, found striking similarities between growths of biological systems and technological performances in some areas. For instance, such a behaviour was even apparent in a chemical reaction in a closed system with a predetermined quantity of reactants. Many of the engineering problems, like matching/achieving the thermodynamic efficiency of an engine to its natural limit of carnot cycle efficiency, manifest such a behaviour. This similarity between biological and technological systems has encouraged forecasters/scientists to use biological growth curves for technological forecasting.

Two methods namely Pearl curve and Gompertz curve are widely used in forecasting such growth patterns.

Pearl Curve

Raymond Pearl (an American biologist) had shown that increase in population of organisms follows a growth pattern in an `S' shaped curve (Figure 4.2). Pearl's growth curve equation could be adapted for the growth of performance of technology with reference to functional capability which is given by

$$y = \frac{L}{1 + ae^{-bt}}$$

Where y = State of information or performance of technology or functional capability of technology at time t,

L upper limit of growth
t = time, a and b are constants.
'y' has an initial value of zero at 't' = $\propto$
and reaches the maximum value of L at time t = $\propto$. The curve is symmetric about its inflection point y =1/2 L.

The constant `a' determines where the curve will be on the time axis. The constant `b' determines the steepness of the sharply rising portion. On the basis of some historical data points we determine the values of `a' and `b' which give a good fit to the data and then use the equation to forecast future progress as explained below.

The Pearl curve equation can be rewritten as

$$\frac{L}{y} = 1 + a\,e^{-bt}$$

$$\text{or, } \frac{L}{y} - 1 = a\,e^{-bt}$$

$$\text{or, } \ln\left(\frac{L}{y} - 1\right) = \ln a - bt$$

$$\therefore\ Y = \ln a - bt, \text{ where } Y = \ln\left(\frac{L}{y} - 1\right)$$

When Y is plotted against time we get a straight line which can be extrapolated into the future. This is the basis of graphical procedure for projections based on growth curve.

From the historical data we obtain a value of Y, corresponding to time t, and then carry out the minimization of

$$\sum_{i=1}^{n} (y_i - \ln a + bt)^2$$

to obtain a regression fit of Y on t. From the future value of ln $\left(\frac{L}{y} - 1\right)$, he expected functional capability at that time can be calculated. The initial slow rate of growth is caused usually by the resistance to the use or acceptance of the new technology. The upper flattening is due to approaching of a limit, which is physically the maximum possible attainable value. The performance of single technologies follows this type of S behaviour but the overall growth of technologies will be a net result of the growth of individual technologies.

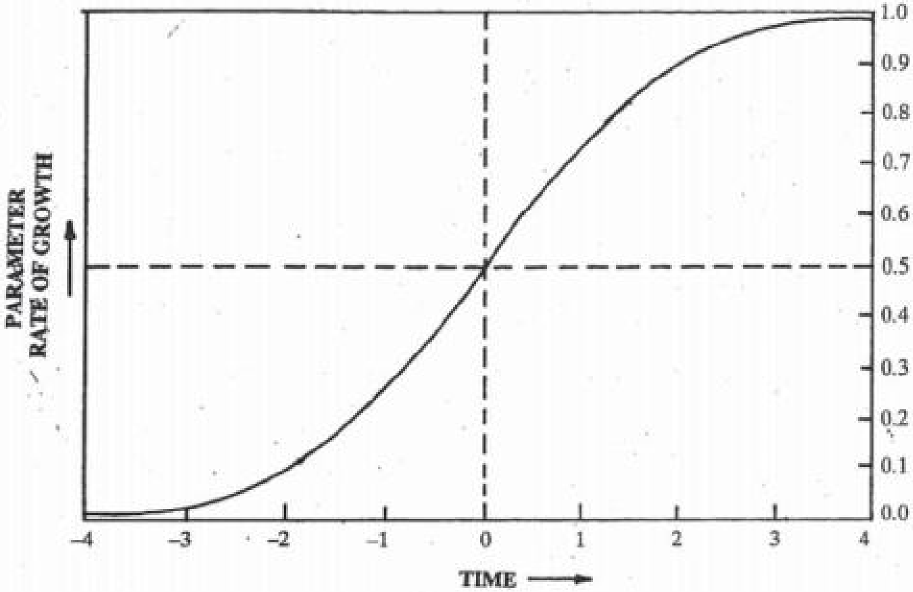

Figure 4.2 : Pearl Curve

Gompertz Curve

This is another growth curve of the same class, named after its inventor-mathematician Benjamin Gompertz, that is frequently used in technological forecasting. It is represented as

$$y = L\, e^{-be^{-kt}}$$

Where, y= parameter of technological growth or a parameter representing technological capability

L = Upper limit of the parameter
b and K are constants
t = time
Like the Pearl curve the Gompertz curve (Figure 4.3) ranges from zero at t = - ∞, to the upper limit L at t = ∞. However, the curve is not symmetrical like Pearl curve.

The inflection point occurs at

$$t = \frac{\ln b}{k} \text{ where } y = \frac{L}{e}$$

The equation of Gompertz Curve can be rewritten as

$$\ln\left(\frac{y}{L}\right) = -b\, e^{-kt}$$

$$\text{or, } \ln\left(\frac{L}{y}\right) = -b\, e^{-kt}$$

$$\text{or, } \ln\left[\ln\left(\frac{L}{y}\right)\right] = \ln b - kt$$

When In (L/y) is plotted against time t, we get a straight line. Sum of least square method can be used for fitting the historical data for this curve also.

This curve can be used to predict the state of technology for which there is a limit, and when the growth in the initial stages is comparatively faster than that of the Pearl curve. Many technological trend capabilities have shown this type of growth. Data representing the functional capability of many technologies may follow one or more of the growth curves. Predictions into the future can then be made using a few initial points.

Applications

Growth curves could be used for forecasting how and when a given technical approach will reach its upper limit. Analysis of most of the technologies shows that when a technical approach is new, growth is slow owing to initial problems. Once

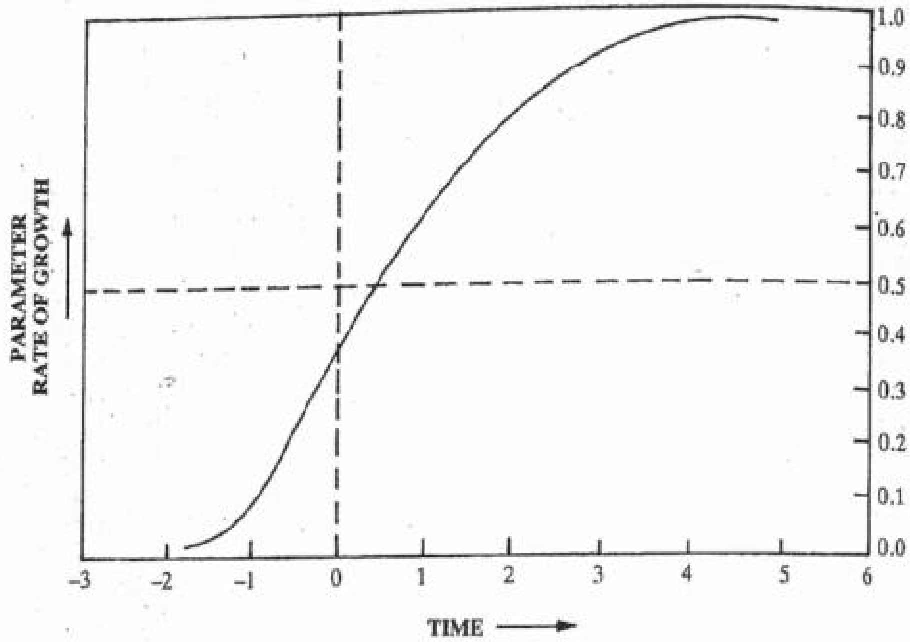

Figure 4.3: Gumpertz Curve

these are overcome, growth in performance is rapid. As the limit is approached, additional increments in performance are difficult. Growth curves can be used for forecasting parameters having a limit and they are useful for estimating demand for new technologies, performance characteristics of newer technological approaches etc. Conventional forecasts using linear extrapolation fail in case of systems which are growing but are bound by a limit. If extrapolation is done using initial data it leads to underestimation. Conversely, if extrapolation is based on the rapid growing trend it leads to overestimation.

Advantages and Disadvantages

This is the only approach which can be used when the system is bound by a limit, be it natural or otherwise. When one has a set of historical data, it has to be decided which of the growth curves will be appropriate to use. Pearl and Gompertz curves have different applications. In cases of diffusion of new technology, initially there are only few suppliers, few after sales facilities, few users etc. As diffusion progresses further substitution is easier, but easiest applications are normally completed first and the tougher ones later. Under this situation, Pearl curve is more appropriate. But, where Success of diffusion does not make further substitution easier (as in the case of products for reducing population growth in India), Gompertz curve is the appropriate cWce.Once again for making an appropriate choice of the model to be used,'adequate and authentic past data is a must. The problem of determining the limit (L) can be overcome by taking the percentage of the parameter for forecasting . (e.g., percentage house to be electrified etc.)

vi) Relevance- Trees

The concept of relevance tree, one of the normative methods, was first described -by . C.W. Churchman et akin 1957. In this method the objective to- be achieved is divided into ,a set of major•activiti'es. Each activity is broken down farther into missions and each.mission is subdivided into a task. Then the deficiency with respect to the specific task is identified based on which a project or an action is recommended. It thus involves a hierarchical listing of tasks as well as its alternatives and each branch is thus to be considered as a goal; sub-goal etc. The main advantage of the method is that the objectives and the actions to be taken get linked.

A relevance tree is shown in Figure 4.4. Relevance tree enables the planner to assess systematically all the interlinked technologies and tasks which could lead to the achievement of an objective. We can then select the most appropriate path to do so.
The method consists of the following steps

Step 1 : Arrange in hierarchical order the objectives, sub objectives, activities, 20 missions or tasks.
Step 2 : Ensure that all possible ways of achieving the objectives have been included or assessed:

Step 3: Evaluate the relevance of individual tasks and sub-objectives to the overall objectives.

The relevance tree technique serves as a tool both for forecasting and planning process.

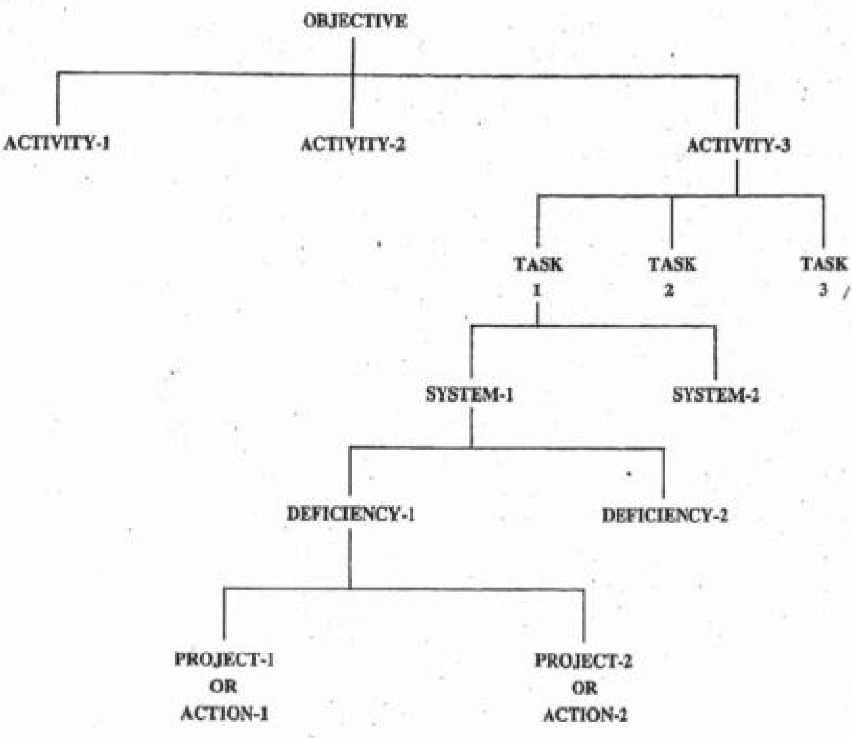

Figure 4.4 : Relevance Tree

Relevance tree technique not only determines and evaluates systematically the alternative paths through which a normative objective or a mission could be accomplished, but also provides an insight into problems that have to be surmounted to achieve a goal. Many R&D type problems are amenable to such analysis by means of a "Problem Relevance Tree" analysis. Figure 4.5 below depicts such a situation for development of a Solar Car which has potential to provide a pollution free mode of road transport.

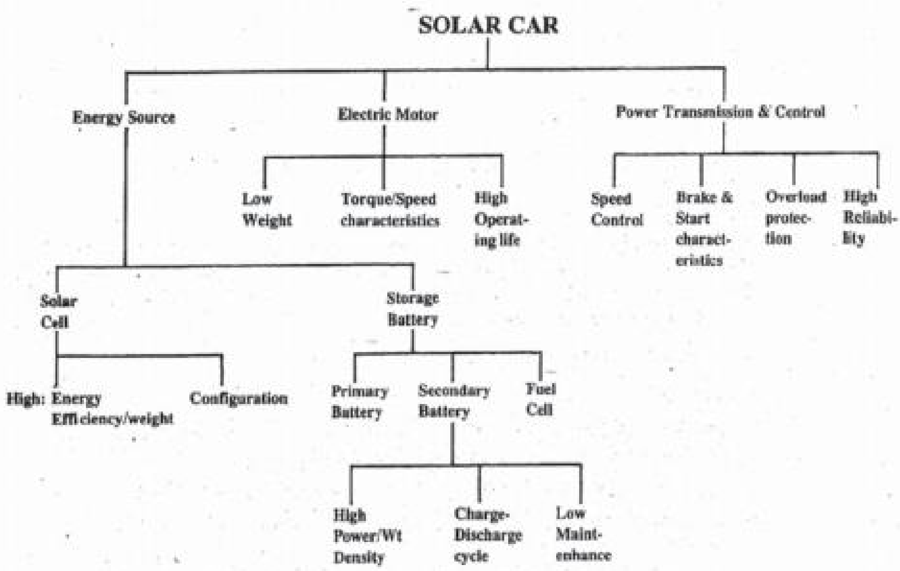

Figure 4.5 : Problem Relevance Tree

In this case, we are attempting to examine the issues of designing a solar car by considering the major problems that are to be solved in the sub-systems and sub-sub-systems, and so on. It is important that all the technological problems emanating from a node must be solved before the predetermined goals for that node are achieved and thereby enabling us to design the solar car finally.

You should try to build such relevance trees for specific technologies/ products you are familiar with. While doing so you will realise the need of arriving at/deciding the quantum of inputs required at different branches to reach a node. This quantitative judgement is essential since the decision maker, based on these estimates, would allocate resources in terms of men; materials and money, commensurate with the importance of the task/activity for solution of a problem. To analyse the problem rationally, a scheme of applying "relevance numbers" to each branch of relevance tree was developed at Honeywell. Figure 4.6 illustrates a relevance tree with relevance numbers. To cover all possibilities the tree must have an exhaustive listing of all the alternatives. There should not be any overlap between the branches at one node to ensure that alternatives are mutually exclusive.

The objective `O' can be achieved by completing all the three tasks, T_i, T_2 and T_3, (Figure 4.6). Each task can be assigned a relevance number proportional to the relative importance of the task in achieving the objective. Each task can be achieved by one or more approaches. Each approach is assigned a relevance number in turn. For each task and approach the relevance numbers assigned are normalised such that they add up to one. By multiplying the relevance numbers of each task and the approach following a particular path, the relevance number of each path can be obtained. The relevance-numbers so obtained and shown in the boxes under each approach indicate the relative inputs required for each path to achieve the objective.

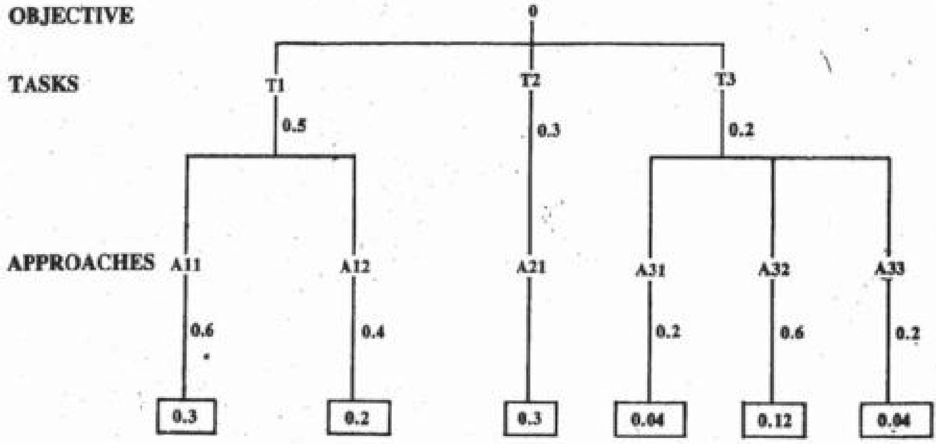

Figure : 4.6 Relevance Numbers

Applications

Relevance tree is a powerful and general-technfque with a wide range of applicability. It can be used for identifying new system alternatives and this can be a technique for obtaining divergent solutions to a given problem, or for obtaining a convergence for integrating many of the subsystems.

Advantages and Disadvantages

Advantages

a) provides a systematic method for assessing the route to be used for achieving a defined future objective or solving a given problem,
b) helps in deciding whether an objective is likely to be achieved or not,
c) 'helps in determining alternative ways by which a given objective might be achieved,
d) establishes the need for carrying out detailed technological forecasts of critical tasks/approaches that are to be achieved in a given time scale,
e) ensures that adequate and appropriate attention is applied to all tasks and activities depending on-their relevance,

Disadvantages

The relevance tree for a large complex technology could become too complicated to be handled.

vii) Morphological Analysis

The morphological approach, another normative technique, was developed by Fritz Zwicky, and involves a systematic evaluation of all possible combinations of solutions to individual parts of a whole system. In this analysis, the whole problem is broken down into parts which could be treated independently with several solutions to each part. The forecast is made on the combination of such solutions of each part to satisfy the desired objective of the whole system. In essence, morphological analysis and relevance tree could be considered as two faces of the same coin. 'Relevance trees' provides a hierarchical structure while 'morphological model' presents a parallel structure of the problem. In general any system or problem could be modelled either by a relevance tree or a morphological structure and the forecaster could choose the appropriate model depending on the problem on hand. For example, we break our solar car, previously referred to, into five independent components having a number of solutions for each as shown in

4.2 : Break up of Solar Car into Components

		Morphology	
Solar Panels	1	2	3
Electric Controls	1	2	
Motor	1	2	3
Energy Source	Solar Cell	Storage Battery	
Type of Storage Battery	Primary	Secondary	Fuel Cell

The various types of elements in `energy source' and "types of storage battery" in morphological model show up as branches in the Relevance Tree in Figure 4.5. Like the relevance tree solutions, once the required levels of functional capabilities are determined by morphological analysis, they could be utilised for forecasting a feasible and suitable configuration of a solar car, estimating the timeframe etc. by obtaining an exploratory forecast of each of the technologies involved in the elements. Note that the problem has 3x2x3x2x3=108 solutions of which some would be rejected immediately based on technological considerations. Systematic analysis would tell the forecaster which combinations of solutions of individual components would provide the desired satisfaction to meet the objective.

Application

Morphological analysis is a useful technique for stimulating the thinking process and allows examination of all combinations of alternatives to achieve the objective.

Advantages and Disadvantages

Morphological models can be used to identify requirements for individual technologies of a specific system, but cannot be used to obtain quantitative estimates of relative importance of various technological goals. This is a static model and is not suited to take care of systems that change with time or describe the logical sequence of events.

Figure 4.7 shows a projection made in the early 1980s when scientists thought the limits to performance might occur - with performance measured as chip density (micro-electronics) or number of transistors per chip. Then it was projected that a natural limit will be reached in the 1990s as lithographic limits become near the resolution of light or x-ray diffraction limits. That this would happen by the turn of the century was the forecast in early eighties. It was anticipated that the limits of semi-conducting material technology might be found in a density of, a billion transistors per chip, called ULSI (ultra large scale integration). After IC_2 came the LSI IC, then the VLSI IC, and finally the ULSI IC has been developed.

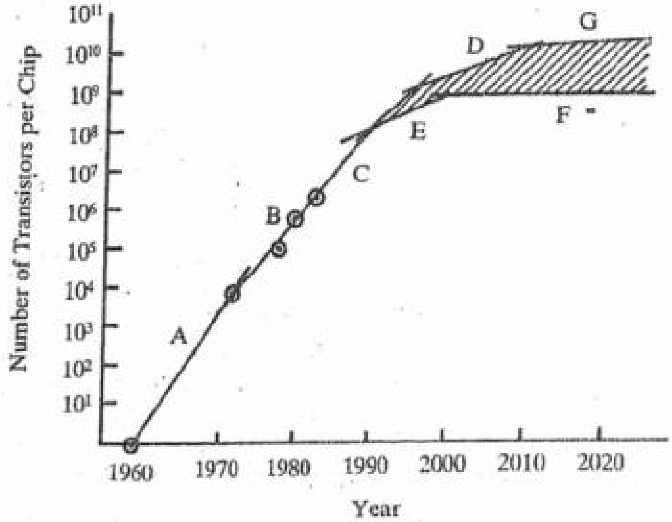

Figure 4.7 : Technology S-Curve for Semi-conductor Chip Density Progress
Source : Betz, Frederick, 1987, Managing Technology, Prentice-Hall, p. 67.

4.8 COMPARISON OF METHODOLOGIES

The choice of selecting an appropriate technique for a particular forecasting exercise is a complex problem. The methodology that is adopted depends on the purpose for which a forecast is being prepared. The approach to be used depends on the following factors:

a) purpose for which the forecast is being made
b) reliability needed for the forecast
c) precision of the available data
d) the time frame for the forecast

However, a general comparison of the major approaches of forecast (on a 1-10 scale; 1 being lowest and 10 highest is given in Table 4.3 below :

Table 4.3 : Comparison of Techniques of Forecasting

Technique	Use of intuition	Complexity	Resource requirements	Identification of alternatives
Individual Expert	10	1	1	Yes
Delphi	10	3	3	Yes
Trend Extrapolation	4	1	1–2	No
Growth Curves	4	4	3	No
Technology Monitoring	1	2	6	Yes
Relevance Tree	7	8	4	Yes
Morphological Analysis	7	8	4	Yes

(Adapted from S.C. Wheelright and S. Makridakis, 1973. Forecasting Methods for Management, Wiley, New York.)

The ultimate test of goodness of a forecast is whether it is accepted and used in the decision making process. The' forecast must be understandable, credible and meaningful to the decision maker.

4.9 COMMON MISTAKES AND PITFALLS

Following is a list of common mistakes and/pitfalls in technological forecasting:

i) Failure to use appropriate data

a) use of unreliable and inconsistent data
b) failure to use valid, available data due to the use of wrong technique
c) use of imprecise and incomplete data with a sophisticated techniques etc.

ii) Mistakes in selecting appropriate methodology

a) use of inappropriate technique
b) inability to handle intrinsic uncertainties
c) reliance on single expert
d) overemphasis on quantitative techniques, etc.

iii) Lack of imagination in the form of

a) failure to distinguish between signals and noises
b) acceptance of trends as rigidly continuing
c) reliance on limited information
d) neglecting uncertainty, etc.

iv) Biases introduced by personal factors -

a) vested interest of the forecaster
b) unwillingness to alter other previous commitments
c) over optimism or pessimism
d) avoiding unpleasant courses of, action, etc.

Activity 2

Has your organisation ever attempted to make a technology forecast. Say `Yes' or 'No'.

a) If yes, what method(s) has(have) been used and why? What benefits your organisation has derived from such a forecast?

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b) If no, why a forecast was not made, especially when you think it could have been made. What obstacles, including lack of resources, your organisation faced?

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Activity 3

Identify with respect to your organisation.

a) What activities would be benefited by technology forecasting?

b) Which methodology or which combination of methodologies of technology forecasting would you use? Explain the reasons and justifications for your choice.

c) Within the resources at your command, undertake technology forecasting for one activity/sub-activity.

d) Present the results of the forecast to the decision maker and find out if it is of any benefit to him. If not, why not? Are his reasons convincing?

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4.10 SUMMARY AND CONCLUSION

The seeking or anticipation of technological innovation has been called Technology Forecasting. Over the years, fairly tried and tested techniques have been developed for technology forecasting. However, the forecaster has to select the appropriate methodology or a combination of methodologies to make his forecast understandable and credible. This depends upon the nature of technology forecast and availability of reliable data. The forecast, if appropriately and judiciously made, could serve as a valuable tool for decision making for applying mid-course correction in a plan, or for launching new activities or businesses with a view to achieve the desired objectives.

It may be emphasized that a forecast never forces a decision. The decision maker has all the freedom at his command to act judiciously and he is not bound by the findings of a forecast. In fact, the forecast makes him aware of alternatives which he might not have otherwise discovered al}d thereby it increases his freedom to act the way he thinks best and helps him to improve the quality of his decisions.

In India, Technology Forecasting has not been really popular in the S&T framework as a whole and in industrial enterprises in particular, although some initiatives have recently been taken by the Government. A Technology Information, Forecasting and Assessment Council (TIFAC) has been recently set up in DST by the Government, essentially to assess the technological needs and available technologies, as well as to make forecast for the future trends in technologies, particularly on long-term basis and in broad sectors of economy.

4.11 KEY WORDS

Forecasting : Predicting what the future is going to be which is an essential element of any planning process.

Technology Forecasting : Prediction of future characteristics of useful machines, products, processes, procedures or techniques. It is also defined as "the seeking of or anticipation of technological innovation" and is an important management function.

Role of Technology Forecasting Technology forecasting serves as an input to the process of making plans and decisions for future expansion or new businesses or even to remain in the market.

Technology Forecasting Methods : Methods or techniques to forecast future technological trends and needs. They may have varying degrees of 'success or use" depending upon the requirements, capabilities and policies of management.

4.12 SELF-ASSESSMENT QUESTIONS

1) What is Technology Forecasting? Discuss its role at national and enterprise levels.
2) Explain the essential elements of a technology forecast? How do they influence the decision making process?
3) What is meant. by innovation chain? In what way does Technology Forecasting affect or influence technology innovation chain?
4) What are the factors that have necessitated the use of technology forecasting as a tool for management? Explain briefly, with reasons.
5) What do you mean by exploratory and normative methods of forecasting? Explain any one technique briefly under each methodology, giving the range of applications and the associated advantages and disadvantages.
6) "In India Technology Forecast is generally made on the basis of the literature survey, available data/information, market requirements, Government policies and support mechanisms." Comment.
7) Make a technology forecast for the next 10 years, 20 years for a product being manufactured by your organisation or that you know of. Give the basis and usefulness of the forecast.
8) Give any two examples of the Technology Forecasts for the next ten years available in advanced countries. Indicate possible advantages and disadvantages of those technology forecasts for India.
9) Which are the organisations dealing with Technology Forecast issues in India? Give a brief account of the work being done by them.

4.13 FURTHER READINGS

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Rohatgi, P.K., Rohatgi, K and Bowonder, B.', 1979. *Technological Forecasting, Tata* McGraw Hill, New Delhi.

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1. Martino, J.F., 1983. *Technological Forecasting for Decision-making.*
2. *Betz, Frederick,* 1987. *Managing Technology*, Prentice Hall, pp. 66-68.
3. Bowonder, B and Miyake, T., 1990. *Technological Forecasting : Methodologies and Case Studies* (Report III) TIFAC, DST, New Delhi 1990.

UNIT 5 GENERATION AND DEVELOPMENT

Objectives

After studying this unit you will be able to :

- understand the process of technology generation and development, and its importance at national and firm levels;
- understand the need for technology strategy for continued competitiveness and growth of a firm;
- understand the determinants and their interrelationships in technology generation;
- know the various approaches available for development of technology at enterprise level;
- understand the importance of R&D and various inputs required to translate R&D efforts to technology;
- organise an appropriate technology development infrastructure at your organisation.

Structure

5.1 INTRODUCTION

In the previous unit, we studied the need for and methodologies of technology forecasting for the planning of business and economic activities at enterprise and national levels. In this unit, we shall study various issues relating to generation and development of appropriate strategy in accordance with the macro and micro level plans and objectives.

Generation and Development of Technology is a complex process involving several steps ranging from concept or idea to basic research to utilisation of technology, taking into account the social, economic and political environment at national and international levels. Technologies are generated through R&D efforts in laboratories and developed in the form of usable products through several stages. At macro-level, the national governments formulate policies, measures and mechanisms to provide supportive structures and facilities for micro-level generation and development of industrial technologies and for technologies of strategic importance requiring large investments. The international agencies, for example agencies of the United Nations, also support such efforts. At micro-level, the generation and development of technologies is mostly related to the business activities of an enterprise. The macro-level and micro-level efforts are expected to be complementary to each other. However, in practice, the two interests sometimes tend to conflict with each other. For example, while a government would like to encourage environment-friendly technologies in the general interest of the society where profits may not be the prime objective, an enterprise may like to pursue technologies which produce maximum profits or further its business interests on short-term or long-term basis.

The national efforts are primarily directed towards development of `generic' technologies (e.g. materials), which have a bearing on industry and society as a who' while the enterprise efforts are mostly confined to their areas of operation and specific to products and services. In advanced countries, basic research is mofunded by the government and public agencies, and industrial research is funded by industry. In most of the developing economies, almost all types of research and technology development are susbtantially funded by the governments. Further, total funding levels on technology generation and development are much higher, in absolute terms as well as percentages of GNP in industrially advanced economies than developing economies. F o r example, funding levels of R&D as a percentage of GNP has averaged around 2.5 to 2.7 in the 1980s in USA, West Germany and Japan; while the same was around one per cent in 1990 in India. The importance of R&D i n international competition can be felt by. the fact that the trade balance of various developed countries in research intensive areas is more than in non-research intensive *areas.* This shows the importance of advance technology in world trade. Ever since the Industrial Revolution, technological innovation has been an important factor in international competitiveness. For example, micro-electronics and computers is an area where developed countries have a clear superiority over developing countries while in established sectors such as Cement, Fertiliser, Steel, Textiles, Sugar etc. the technologies are fairly matured in the developing countries and many of them have indigenous capabilities. Developing countries generally continue to make efforts to generate and develop technologies which have already been developed and used elsewhere because these technologies are not readily available for transfer due to various socio-political and economic considerations. However, incremental developments do take place as a result of absorption and adaptation efforts. The result is that developing countries continue to depend on developed countries for technologies, capital goods and services in most of the sectors. Most of the firms continue to import technologies/goods/services and are perpetually dependent on foreign sources and do not invest adequately on R&D to build-up their competitive strength. Thus, it is extremely important to pay adequate attention to the generation and development of technology at macro as well as micro-levels.

Activity 1

With deference to your own organisation or any other related organisation to which you have access, ascertain the following:

i) What importance is attached to generation, upgradation, or improvement n technology?

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ii) Does the'orgaitisatiori have its own R&D lab? What kind of activity is done in it? What percentage of total sae/revenue is spent on R&D?

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iii) What have been the achievements of R&D in the generation, upgradatien or absorption of technology?

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5.2 TECHNOLOGY STRATEGY

Whether or not an organisation would generate or develop its own technology and with what intensity it would persue the efforts in this respect would depend upon **technology** strategy it has formulated or adopted. Let us, therefore, first see what a technology strategy is, what could be the different types of technology strategies, why is it important to have a technology strategy, and how could we link it with the overall business of an organisation.

Though the term `strategy' is commonly used as an antonym of `tactics', it actually implies long-term, purposeful and interconnected efforts, while tactics imply action to deal with immediate specific problems. "Technology Strategy" may accordingly be defined as a strategy to deal with the technology and related issues at macro and micro levels, with respect to set objectives.

Macro level Strategy : At macro level, each country outlines and adopts a technology strategy to achieve its political, economic and social objectives and translates the same into action through appropriate policies and mechanisms. These strategies may be different for different countries. For example, US may adopt to excel in "defence" or "warfare technologies" or in generation of first stage new technologies for knowledge-based industries, while Japan may decide to excel in technologies for consumer products of newer designs at lower costs. Korea may decide to adopt and upgrade imported technologies using mass production techniques for consumer products without really caring much for aesthetics or high quality levels, and without bothering for defence or other strategic applications. On the other hand, India may decide to develop its own capabilities in strategic areas such as defence, atomic energy and space where technologies are usually closely guarded or for maximum utilisation of its own resources. It may thus train S&T manpower, generate employment, promote rural development, check population, and so on. India's thrust has been on a strong scientific base while countries like Korea, Taiwan, Singapore, Thailand have given attention to developing technological capabilities, at least on short-term basis Some countries may adopt technology strategies for building up export=oriented economies as in the case of Japan and Korea, while some others may prefer to have technology strategies for import substitution as is case of India, Pakistan, Bangladesh. Thus, technology strategies may vary with the national perspectives, and accordingly policies and mechanisms are evolved and implemented. Financial resources play an important role in evolving the technology strategies..

Depending on the resources available and the will of the government', the policies are evolved, mechanisms are set up and measures are taken to ensure the achievement of the set objectives.

Micro level Strategy : The extraordinary range and potential uses of contemporary technology have important consequences for industrial and commercial firms. The industrial and organisational turbulence engendered by technological change and increasing international competitive pressures provide threats and opportunities for firms. An effective strategic approach to technology allows firms to cope betterwiththese changes, and reduces the threats and insecurities facing them and their employees.

The basic role of technology strategy in business planning is to help ask the questions like : what business the corporation plans to be in and how it be positioned? Effective planning identifies the present decisions required to create desirable and competitive corporate futures. In particular, technology strategy must anticipate the transient impact of technological innovation on the future competencies of the corporation. An appropriate level of formal planning provides systematic and documented strategy The inputs to the process occur through participation of staff and line management and of special planning groups. Technology scenarios should help management focu on the interaction of changes between technology and change in markets, resources, regulation and competition'.

Some of the arguments, based on experiences and case studies in several countries, relating to technology strategy include :

- The existence of a corporate strategy is increasingly necessary for industrial firms and is necessarily long-term. It is appropriate for all companies except the very smallest. Technology strategy should complement other elements of corporate strategy.: manufacturing, marketing, investment etc., and should in many cases be international in focus.
- Strategies extend beyond the boundaries of the term to encompass the behaviour of other companies - suppliers, customers, partners and competitors - and other sources of technology. Public policies can directly affect the technological activities of firms and must be taken into account.
- Strategy formulation, implementation and review are processes which are susceptible to radical change through the intervention of managers. There are benefits to be obtained by basing strategy upon those accumulated competencies which provide comparative competitive advantage, and through complementing those competencies with external expertise. A crucial factor underlying successful strategy is the ability of managers to adapt and learn from experience.

Importance of Technology Strategy : Mark Dodgson has identified the following five issues which bear on the importance of corporate strategy for technology[2]

i) The need to cope with technological uncertainty;
ii) Complexity and discontinuous nature of technological development;
iii) The need for technology to be viewed in a global context;
iv) The need to attain complementarities, and
v) The relationship between corporate strategy technology and public technology policies.

Linking Business and Technology Strategy : According to Fredrick Betz the basic role of technology strategy in any business planning is to pose three fundamental questions[3]

i) In what business should the firm engage in future?
ii) How should the firm be positioned in these businesses?
iii) What research, production and marketing will be necessary to attain those positions?

An example of a major change in business plans arising from technological considerations occurred in Monsanto (USA) in the early 1980s. From the late 19th century,, the chemical 'industry was a continuously innovative and growing hi-tech industry. The phase of technological change in the chemical industry followed the classic S-curve, exponentially exploding in the early 20th century and growing linearly into the later 20th century. Then in the late 1970s, there arose a possibility that the basic chemicals industry would become mature technology industry. At the same time world-wide industrial capacity to produce commodity chemicals outgrew demand. Technology transfer of chemical knowledge to less developed countries has shifted the competitive edge from knowledge advantages to resource advantages. Petrochemicals were going through a technology life cycle and several countries like South Korea, Mexico, India and other developing countries are building petrochemical plants to meet their own needs; more important, some importers, particularly Middle Eastern countries, are about to become big exporters themselves. Therefore, the traditional exporters in the USA, Western Europe and Japan are now looking for ways to safeguard their home markets. The large American chemical firms had to plan new strategies. In the early 1980s, Monsanto re-oriented its technology strategies to reduce costs in its traditional business areas while positioning itself in new technologies and new businesses. As a result, the traditional business of Monsanto (basic chemicals) would become only 1/3rd of Monsanto's future businesses. Monsanto sold a number of losing businesses in the United States and abroad and at the same time bought a number of small companies, to fit into new electronics operation and invested heavily in biotechnology. This is one result of the strategy based on integrating technology into business planning - parts of the company continue, parts are discontinued and new parts acquired or begun. Monsanto had turned its long range strategy towards the hottest new, major technology then unfolding - biotechnology.[4]

Formulating a Technology Strategy : In planning technology strategy for competitive advantage the following steps have been suggested

1. Identify all the distinct technologies and sub-technologies in the value chain.
2. Identify potentially relevant technologies in other industries or those under scientific development.
3. Determine the likely **path** of **change** of key **technologies.**
4. Determine which technologies and potential technological changes are most significant for competitive advantage and industry structure.
5. Assess a firm's relative capabilities in important technologies and the cost of making improvements.
6. Select a technology strategy, encompassing all important technologies, that reinforces the firm's overall competitive strategy.
7. Reinforce business unit technology strategy at the corporate level.

Small and Medium Enterprises : The small and medium enterprises play an important role in the overall industrial and economic development in developed as well as developing countries including India, although the size and definitions may vary from country to country. In India, small scale sector contributes to about 50% of the total industrial production, about 30% of total exports, and provides employment to over 12 million people. Many of the small businesses are promoted and managed by technologically innovative entrepreneurs and managers. These units often enjoy preferential treatment in financing and marketing but lack resources in terms of investments, manpower, equipment, etc. The scales of operations are low. Therefore, the business strategies and requirements of small companies are different than those of large and corporate companies. Accordingly, the technology requirements and technology strategies also are different since their capacity to invest in technology is limited. However, there are many companies who have technological awareness and capabilities and are innovative in nature. It is reported that many of the European small and medium enterprises have virtually limitless potential to develop and utilise new technologies.[5] The major factor underlining their success and growth is the quality of their management. Technological entrepreneurs are "born entrepreneurs" and cannot be reproduced, while professional managers can be trained. They are aware of all the limitations and possibilities of small firms, and are capable of identifying, encouraging and nurturing entrepreneurship. The world-wide experience shows that companies having successful management of technology and effective strategies for technology are more successful overall than others. Also, technology innovative companies have a better chance of independent operations and sustained growth than others. In India, the awareness about the importance of technology strategies and investments in technology generation and development is growing, in ,the small scale sector in particular, in the context of new policies announced in the later part of the year 1991.

Activity 2

Does your organisation have any technology strategy? What is that strategy? Arrange a meeting with a knowledgeable executive of your (or any other technology intensive) organisation and discuss with him the ingredients of technology strategy. Also discuss with him the action plan to accomplish the strategy.

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Activity 3

As a manager or officer of the segment under your charge, you have probably to do something with the technology aspect. What and how would you like to develop a strategy in relation to the technology aspect?

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5.3 TECHNOLOGY GENERATION

Technology generation and development Is often synonymous with the term "research and development (R&D)". However, technology generation involves R&D efforts while technology development involves further stages of translating R&D efforts into marketable products, processes and services. Basically, one can consider the R&D process as having four distinct stages as shown in Figure 5.1. Recognition of a need for innovation is one of the motivations for R&D. "Research" on existing knowledge for satisfying identified need helps in idea generation - this is the "need push". The other primary motivation for R&D is to find potential applications fgr advances in knowledge. "Research" on existing activity for introducing new knowledge also helps in idea generation - this is the "technology-push". "Development" includes engineering (creation, design and production) and marketing (first use and diffusion) of the generated idea. Through the entire process it is ideas and knowledge which are being pursued.""and the process is not complete until the new idea is converted into a marketable product or service (a hardware or software intensive technology).[6]

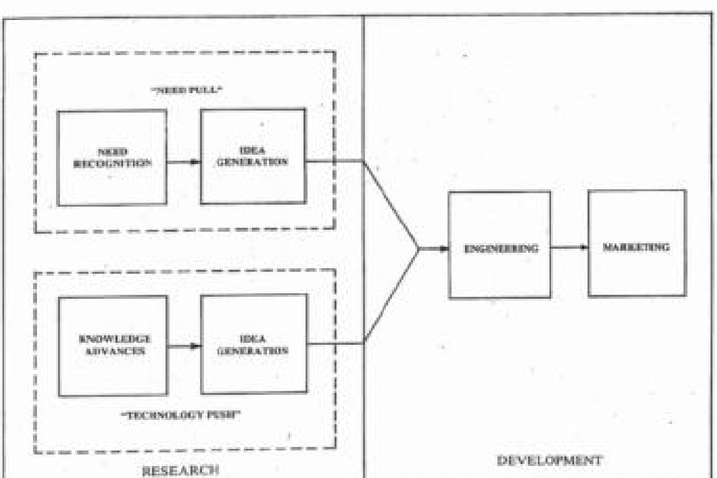

Figure 5.1 : Stages of R&D Process

Source Sharif, Nawas, 1983. Management of Technology Transfer and Development, APCTT Bangalore, p. 89.

Objectives of Corporate R&D and R&D Projects : Corporate research and development is the principal corporate asset for long-term technological competitiveness. Corporate research activities can be classified by the purpose of the research :

1) To support current businesses;
2) To provide new business ventures;
3) To explore possible new technology basis.

As explained earlier, the R&D projects tend to go through the following stages :

1) Basic research and invention;
2) Applied research and functional proto-type;
3) Engineering proto-type and testing;
4) Production proto-type and pilot production;
5) Product testing and modification;
6) Initial production and sales.

Stages 1, 2, 3 are usually called "research" while stages 4 to 6 are called "development'. Hence, the term "research and development (R&D)".

Each stage of innovating anew product is expensive, with the expense increasing by an order of magnitude at each stage. The management decisions to continue from research to development are therefore very important. Overall, the expenses of modern industry for R&D were considerable. For example, in USA in 1981 the industrial expenditures for R&D were US $ 49 billion representing about 1.7% of GNP in that year. Of this US $ 49 billion, about 25%, was for research and 78% for development. The major purpose of research is to reduce technical risk before production - scale investment is committed. It is generally reported that at each stage, the cost escalates by orders of magnitudes of over 1 : 10. It is precisely this reason that technology generation and development is costlier than basic R&D and hence all countries or all enterprises are not able to pursue these activities at similar levels.

Corporate Research and Product Life-Times : R&D projects in corporate research create and extend the life times of corporate products, avoiding technological obsolescence of businesses. Extending product life times can be done by :

1) Improving the production processes to lower production costs and increase quality;
2) Upgrading and improving current product models;
3) Creating next generation product models.

The function of corporate research is to create and extend the lifetimes of the company's products. This is an essential function because all products have finite lifetimes (sometimes as short as one year and sometimes as long as several years). In times of new and rapidly changing technologies, lifetimes tend to be short. A mature technology product may have a very long life time if no clearly superior technology has emerged. But even in a long lived product, periodic reformulations, variation in product lines, and changes in packaging provide some change in the product. To maintain a long lived product, quality must be maintained on par with competing products, if not more, and cost reduction in production must be ahead of competitors. Product lifetimes are dependent on two factors : technological obsolescence and product substitution. Technological obsolescence occurs rapidly and product models have short life times due to new models with improved technical performance. As product life times age, changes in sales volume and profitability should be arrested through introduction of new products by way of R&D efforts.

Production Costs and R&D : Production costs of new products usually decline over times, due to process and product improvement. In any new product line, initial production costs are usually much higher than later production costs. All new products based on new technologies have initially high per unit product costs because of (i) large R&D and plant investment costs, (ii) small volumes of initial production, and (iii) inefficiencies in the production processes and in production design. For a successful product, these factors improve over time. Investment capital becomes amortised over larger production volumes. The increasingly larger volume of production also lowers per unit overhead charges. Innovations and improvemeii ▸ ts in production processes create more efficient production procedures. Later generation production models and computerised techniques are designed to lower production costs.

Market share, profit margins, and pricing strategy etc. : are also **highly** dependent on R&D efforts at corporate level and the efficiency at which R&D is carried-out. The entry into a new high technology market is restricted because knowledge is new and is not widely known. Products then are high priced because sales volume is small and production costs are high. Yet, if the price is held there too long, other competitors can enter with "me too" technology products, since high profit margins and growing markets provide the competitive incentive. However, if prices are reduced in anticipation of production costs being increased in future, a competitor has less incentive to enter, and may incur losses. The strategic trick is for the technology innovator to ride the markets faster than the competitors and enter new products earlier than others. It is precisely due to this reason that open competitiveness encourages innovations as happens in advanced economies while restrictive policies and assured markets through licensing systems discourage innovations as has happened in India all these years.

Process of Technology Generation : Technology is generated in R&D organisations. An illustration of the various inputs required for generation of technologies is given in Figure 5.2. Goals, surroundings, criteria and resource allocation are some of the inputs to R&D, the output of which is technology. The input resources into R&D organisations are the traditional inputs such as money, materials, facilities, energy, labour and management, and the intelligence based inputs such as science, knowledge, skills, information and existing technologies. The effectiveness of any R&D is determined in terms of the 'usefulness' of the technologies it produces with respect to the overall objectives of the corporation.

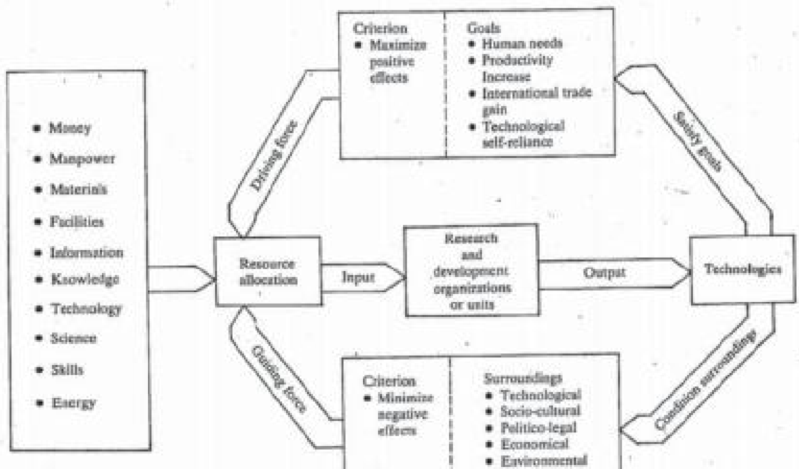

Figure 5.2 : The process of Technology Production

Source : Technology for Development, UN-ESCAPE, 1984, p. 5.

Besides the various factors discussed in earlier paras, the R&D or technology generation involves many other aspects such as, monitoring and evaluation of R&D projects, funding of R&D, training and development of resource personnel, interactions at all levels, management policies and support, the availability of support structures and incentives at government level, timely collection and interpretation of technical and other informations, etc. Some of these aspects have been discussed in detail elsewhere in this course, The quality of resource leadership and commitment of the top management for research is extremely important. In Indian industry or corporate sector, it is generally observed that the research personnel occupy secondary place to finance, marketing and production personnel, and are not given due importance in decision-making at corporate level. Sometimes, inefficient personnel from other departments are posted or transferred to R&D department, thereby indicating a complete neglect of R&D concept. Such management attitudes need to be changed in the overall interest of thg company.

Managing and Monitoring R&D : Managing R&D requires special skills and covers a wide variety of issues ranging from technical matters to management techniques and overall business environment at national and international levels. Managing R&D projects, requires attention to performance, timing, cost, and personnel.

Performance is the measure of a product or process to accomplish a specific function or application. The performance parameters must be defined for an R&D project in order to determine how successfully the goals of the project are attained.

Progress in R&D projects can be watched by monitoring : (i)technicalperformance parameters against time, (ii) performance parameters against cost, and (iii) cumulative cost against time. Timming is important to the success of a project, since lead time created froth timely innovation provides a competitive advantage. Milestone and PERT charts are useful in identifying the necessary tasks and sequencing to accomplish the R&D project. Costs of the project are essential to its commercial success, for R&D costs must be recovered as part of the investment costs in the new product or process. Personnel are also critical part of any R&D project, since the talents, creativity, dedication, and problem solving ability of the personnel are essential to the success of any R&D project.

Activity 4

How are R&D projects managed and monitored at the corporate level? Give an example of a management system for R&D projects used in your ol'gr,anisittion)f any ther organisation that you know.

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5.4 TECHNOLOGY DEVELOPMENT

Though, broadly speaking, the `D' of R&D covers Technology Development, the latter, has much wider connotation. Determine technology development is called for the latter has much wider connection. For better understanding, more elaboration of various factors that determine technology development is called for.

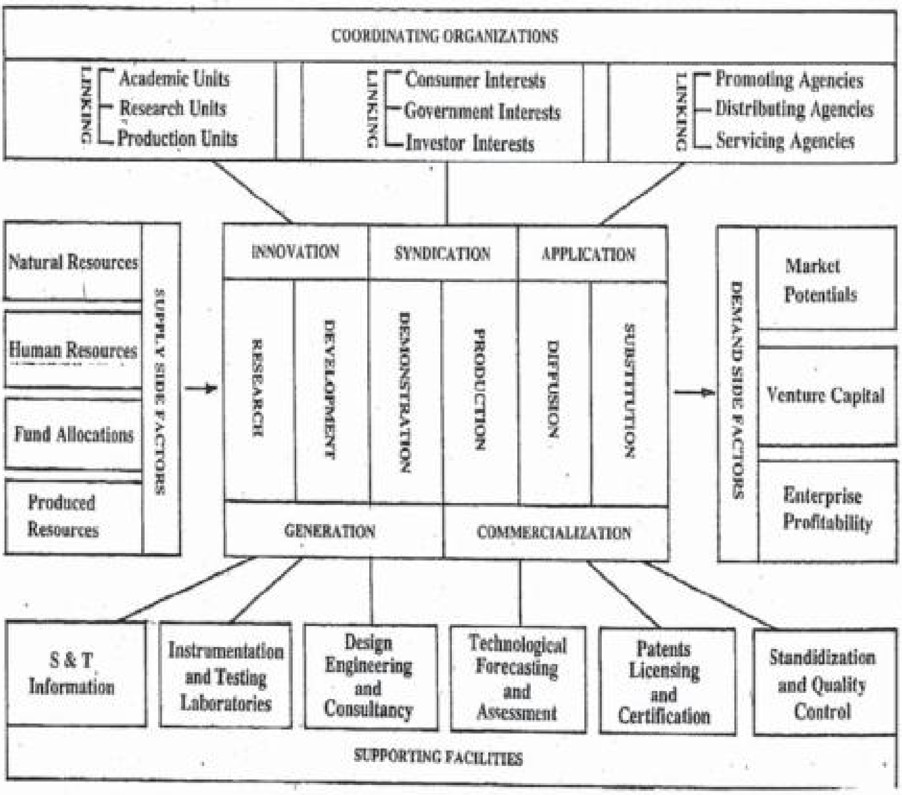

Figure 5.3 : Determinants of Technology Development

Source : Technology Policy Formulation and Planning : A Reference Manual, APCTT, Bangalore, 1986 p. 116

Figure 5.3 shows the determinants and their inter-relationship in technology development from R&D to technology diffusion and substitution. Natural resources are mobilised and processed, through the succeeding stages. The supply factors include natural resources, human resources, fund allocation, and produced resources.

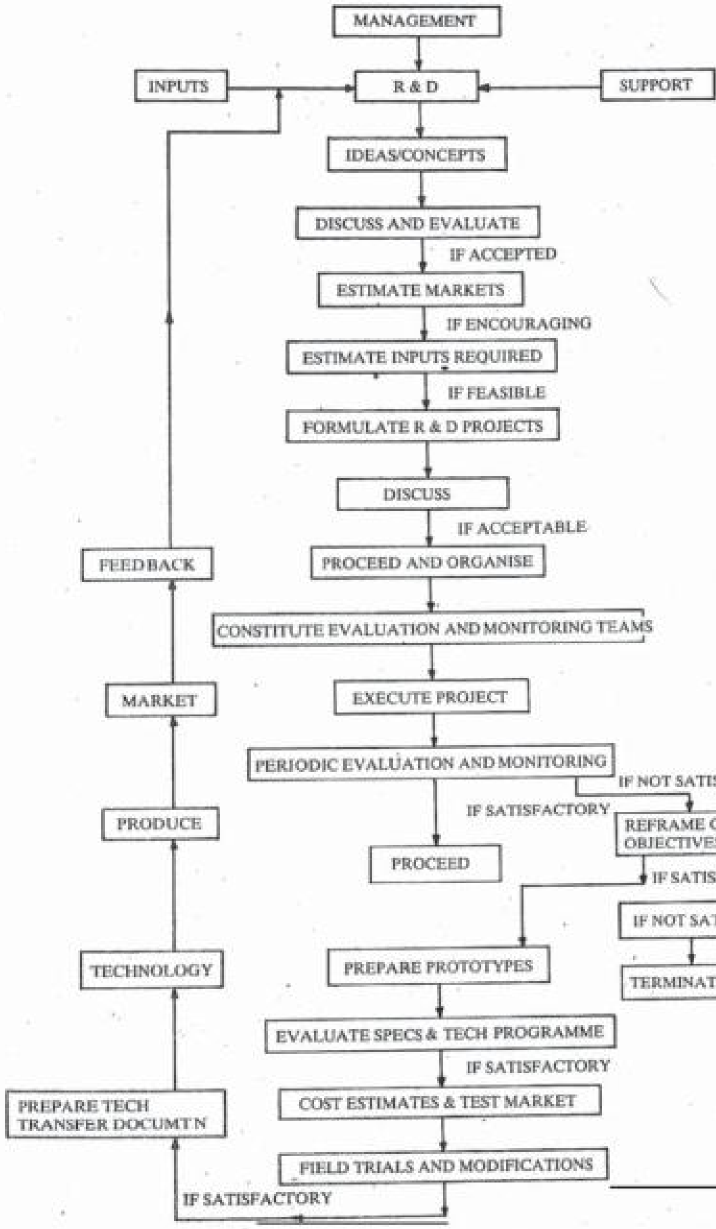

Figure 5.4 : Technology Development Cycle

The demand side factors include market potential venture capital and enterprise profitability. The coordinating organisations, supporting facilities and government policies and systems have a major role to play in the success of the technology development process. Figure 5.4 shows the various stages of technology development cycle, starting from the generation of ideas in the R&D department. It may be observed that this process is a tedious one and requires top management commitment and from outside. Risk factor is large and the success rate depends upon the quality of inputs provided to the R & D department.

Technology Development Approaches

i) **In-house R&D :** Technology development activities are generally carried out through setting up of separate in-house R&D units within the corporation, managed and headed by a well qualified and experienced chief, directly reporting to the top management. However, this unit has close interactions with other departments within the company and there could even be exchange of personnel among the different departments. The strength and facilities in the in-house R&D unit would depend upon the technology policy of the company and the nature of the business. In large companies, there are sometime R&D labs for each department and a central R & D lab for.major R&D projects. Industrial R&D is mostly product or process oriented with specific objectives and time schedule; and not basic research. Incremental developmental efforts or import substitution efforts are generally common in most of the industries in developing countries including India, while emphasis is on new technologies or new applications of technologies in advanced countries.

ii) **Cooperative R&D :** A group of companies in a particular industrial sector promotes an R&D centre as a society or a non-profit making company, the expenses for which are met from the contributions of the participating companies (as a fixed percentage of their turnover) as well as grants from the governments. This centre undertakes R&D as per the requirements of the companies in their larger interest, and sets up expertise and facilities of common nature and which are usually expensive. A company can also sponsor specific projects to this centre. Cooperative research facilities are normally utilised for the projects which are not of secretive nature from the business point of view or first substantial part of the R&D can be done at the centre and the remaining part involving finer details or critical technological aspects effecting the competitiveness is done at the in-house R&D division of the company. National Council of Building Materials (Cement) at New 'Delhi, Textile Research Centre at Ahmedabad (ATIRA), are example of this type in India.

iii) **Contract Research** A company may contract components of technology development to suitable R&D organisations, academic institutions, or consultants or experts, and its in-house R&D unit may coordinate the progress of the activities, to develop the desired technologies. This approach usually requires considerable internal technical and managerial capabilities coupled with a strong S&T information base.

iv) **R&D collaboration :** A company may collaborate with another company in areas of common interest if costs of development are high. Such inter-firm collaborative R&D efforts are becoming common in developed countries mainly due to high costs and shorter technology life cycles, in areas such as micro-electronics, materials, information technologies, Ho-technologies, and so on. A firm may also collaborate with the public funded or privately funded R&D institutions on case-to-case basis where R&D results are shared mutually and so are the expenses. A company in India niay even collaborate With another company or R&D institution abroad, on mutually 'agreed terms. The Govt. of India encourages such collaborations. In such cases, relative advantages of the collaborative partners are the main guiding factors, and is one of the ways to avoid large technology payments in future.

v) **Research Societies :** Large corporations or industrial houses may set up independent research societies, in addition to their in-house R&D units. Such societies may undertake R&D activities mostly relating to the broad interests of the promoting companies in line with the national interests. They will also take advantage of those facilities for the activitieslprogrammes in their in-house R&D unit. Governments usually encourage such societies and provide several tax concessions and fiscal incentives.

vi) **Research Companies :** Large corporations of **technology innovative entrepreneurs** may promote research companies, specifically for conducting research and development of technologies for others on commercial basis. The development costs **and reasonable** profits are recovered from the sale and transfer of **technol** gies. **Such** a concept is common in USA and other developed countries while it is ye to gain a recognition in developing countries such as India. A company may adop any of the **approaches** or a combination of the approaches **depending on** its **needs and resources.** In all the cases, however, in-house technology development capabilities are essential to achieve optimum results with minimum inputs and enhance its competitive position An the acquisition of technology or in the market.

Generation and development of technology is a complex process involving several parameters and steps ranging'from concept;and basic research to utilisation of **technology,** taking into account the soci#l,i economic and political environments or factors at national and international levels, as well as the business strategies of a corporation or a firm. A viable technology ,strategy is important for the continued competitiveness and growth of a firm. The product life-cycles, pricing, marketing strategies, funding, commitment of the corporate management, S&T manpower, are some of the factors that influence or guide the process of technology generation and development. An effective management of R&D and appropriate choice of technology development approaches are important for the success of the technological efforts. The technology development approaches and strategies are different in developed and developing countries as well as for large and small firms. Building of technological capabilities is important for sustained growth and need higher investments for firms, operating in emerging technologies, compared to those operating in areas of matured technologies. National policies and S&T infrastructures are also important 'for the technology generation-and development policies at firm level.

5.6 KEY WORDS

Technology Strategy : may be defined as a strategy to deal with technology related issues.

Macro-level : National and international levels - broader aspects or major issues.

Micro-level : Corporate or enterprise level - limited aspects.

Technology Generation To generate technologies **through R&D** efforts to meet corporate objectives.

Technology Development : To develop technologies i.e. translate R&D efforts to marketable products/processes/services.

Technology Development Approaches : Possible routes or approaches for development of technology, depending upon the strategies and objectives.

5.7 SELF-ASSESSMENT QUESTIONS

1) What is meant by Generation and Development of Technologies? Explain.
2) Generation and Development of Technologies is important for a country's economy. Comment.
3) Explain `Technology Strategy' and its importance at corporate level.
4) Discuss the factors and approaches to formulate technology transfer strategies for large and small enterprises.
5) Discuss *a* general approach for formulating a Technology Strategy.
6) Discuss-the Technology Strategies and Technology Generation process in -
   i) Developed and developing countries,
   ii) Corporate sectors (large and small enterprises)
7) What are the factors to be considered in developing technology strategies and R&D management?
8) What do you understand by `Technology Generation'? Discuss various inputs required for generation of technology.
9) What are the objectives of corporate R&D? What considerations should guide the management in setting up R&D facilities in a company?
10. Discuss the determinants and their interrelationships in Technology Development.
11. Discuss various approaches to technology development. Explain the technology development approach adopted in your organisation or through an example that you know.
12. What are the various stages in Technology Development Cycle? Explain the stages of Technology Development in *a* typical case in your organisation or that you know of.
13. Technology development capabilities play an important role in the competitiveness and growth of companies. Comment with examples.
14. Discuss possible differences in various stages in technology development of a product/process, involving matured technologies and fast changing technologies. Support your answer with an example.

5.8 FURTHER READINGS

Dean, B.V. and J.L., Goldhar, (Eds.) 1980. *Management of Research and Innovation,*. North-Holland: New York.

Gee, Edwin A. *Managing Innovation,* Wiley: New York, 1976.

Twiss, Brian, *Managing Technological Innovation, Essex* England, Longman Group: Harlow, 1980.

References

1 Betz, Fredrick; 1987. *Managing Technology,* Prentice Hall.

2 Dodgson, Mark; 1989. *Technology Strategy and the Firm,* Longman.

3 Betz, op. cit.

4 Dodgson, op. cit.

5 Sharif, Nawaz; 1983. *Management of Technology Transfer and Development, APCTT, Bangalore.*

UNIT 6 TRANSFER

Objectives

After studying this unit you will be able to :

- know the meaning of technology transfer and understand the knowhowtransfer modes and the steps involved in,technology transfer.
- understand the planning for technology search, the identification of appropriate technology for the company, and the factors involved in technology transfer and the routes of technology transfer.
- understand the norms for and factors in pricing of technology, mode of payment, agreements made between the licensor and licensee.
- understand the nature of Government's initiative in technology transfer in advanced countries and the reason for tardy growth of industry in developing countries.
- understand the role of regulatory system vis-a-vis competitive growth of industry, and the need for good information system and data bank facilities.

Structure

6.1 INTRODUCTION

We have studied the process of Technology Generation and Development in the previous unit.Technology once developed can be used by its developer or owner, or can be transferred to another user immediately or after sometime at any stage till maturity, dictated by commercial expediency. Generally, newer technologies are transferred among the developed countries and matured or nearly matured technologies are transferred from developed to developing countries at the enterprise level. In this unit we shall study the process of Technology Transfer and some of the related issues.

Basically there are two ways of acquiring new technology: develop it or purchase it. The second way of acquiring new technology is commonly called "technology transfer". The important reasons for purchasing technology are : (i) it involves little or no R&D investment; (ii) technology can he used quickly; and (iii) technical and financial risks are often quite low. There are also good reasons for selling technology, such as (i) increasing return on R&D investments; (ii) technology may not have immediate use; and (iii) technology has already been utilised upto its limit. Therefore, technology transfer occurs because of the existence of "buyers" and "sellers". The sellers are called "transferees" or "licensors" and the buyers are called "transferees" or "licensees" in the technology transfer process.

Transfer, as defined, means the acquiring through purchase and use of technology. Therefore, the definition of technology transfer is the acquisition and use of knowledge. There is no transfer of technology unless and until the technical knowledge is put to use. Technology transfer is not restricted here only to scientific or engineering items. The manufacturing, marketing, distribution and customer service are among the factors that are included in technology transfer.

The key factors in technology transfer include :

- **Transplantation of technology** involves shift from one set of well-defined conditions to another set in which at least one key variable may differ. Secondly, the recipient may apply the technology to a different purpose from that of the supplier.
- **A sense of opportunism** prevails in technology transfer, whether justified or not.
- The transfer process embraces a **rich variety of mechanisms and relationships** between recipient and donor (supplier of technology). The process can vary from a routine peopleless passive transfer to turnkey contract where the donor takes the full responsibility for all phases of the contract.
- The **nature of the transferred technology** and how it is transferred are critical to the success of the technology transfer process.

Technology transfer may begin as a solution to someone else's problems. Adoption of such "outside solution to solve an `inside' problem is technology transfer. The advantage lies in avoiding "reinventing the wheel".

6.2 MODELS OF TECHNOLOGY TRANSFER

The following Figures (Source : Mogavexo, L.N., and R. S. Shane, 1982, Technology Transfer and Innovation, Marcel Dekker, New York, pp.2-3) illustrate the models of technology transfer :

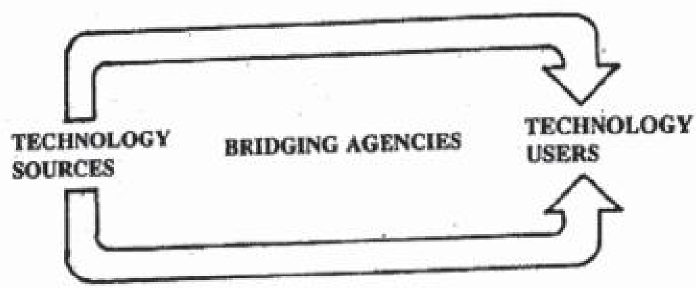

Figure 6.1 : Bridging Agencies

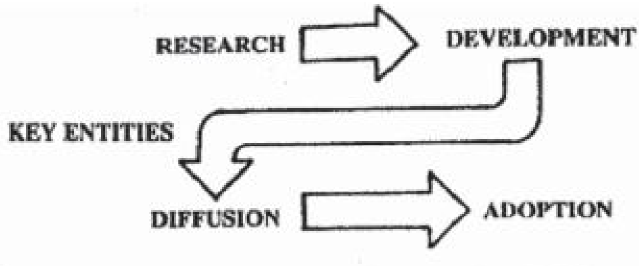

Figure 6.2 : Research and Development Diffusion Model

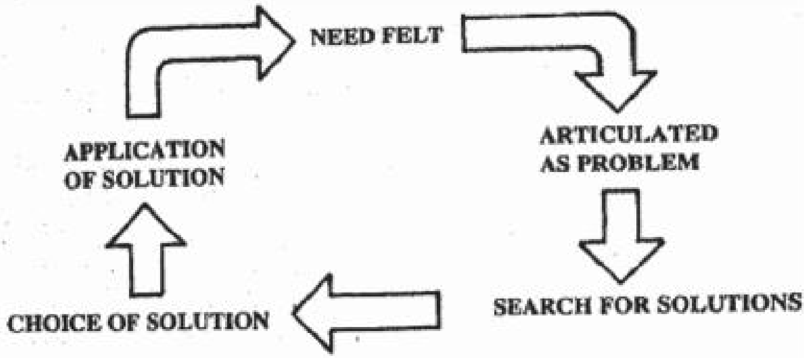

Figure 6.3 : Problem-Solver Model

Figure 6.4 : Technology Transfer Summary Model

Agencies that try to make technology transfers happen include government departments, financial institutions, industries, technology transfer agencies, consultants, venture capital companies, research companies, and R&D organisations, etc. These are the bridging agencies of Figure 6.1. The users of new technologies comprise private and public sector industries, giant technically oriented agencies such as Indian Space Research Organisation, government departments, Atomic Energy Commission etc. It can be seen that a wide spectrum of participants in the total economy are technology users.

Figure 6.2 illustrates schematically the diffusion of technology from a mission-oriented agency that supports development of technology for purposes of its mission and then arranges for the technology diffusion to other industries by knowledge transfer. This is usually a slow process. Figure 6.3 shows the generation and transfer of technology as a companion of problem solving. Figure 6.4 shows a synthesis of the entire process of techndlogy transfer on a large scale.

6.3 TECHCNOLOGS TRANSFER MODES

Technology transfer modes have been categorised basically as being passive or active, which refers to the transferor's role in the application of technology to the solution of the user's problem. This is illustrated in Figure 6.5 (Source : Mogavexco, L.N. and R.S. Shane, 1982, Technology Transfer and Innovation, Marcel Dekker, New York, 1982, p. 15). If the transferring mechanism presents the technology to the potential user without assisting the user in its application, namely by a report or oral presentation, then the technology transfer mode is said to be passive, This is actually knowledge transfer. If the transferring activity assists the potential user in the application of technology, then the techndlogy transfer mode is said to be active, In this process, the transferring activity goes beyond mere interpretation of the transmitted data and advises the potential user on how to apply the technology, or demonstrates the applicability of the technology to the perceived use. There could however be an intermediate also, which may be called semi-active mode in which transferring activity is in between the active and passive modes.

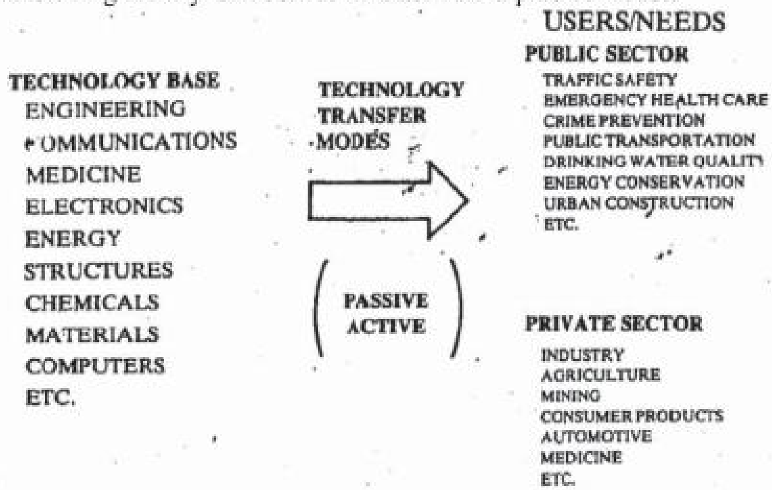

Figure 6.5 : Connecting Technology with Users

The three different types, of technology transfer modes are discussed in detail (Source for Figures 6.6 to 6.8 : Mogavexco, L.N., and R.S. Shane,1982, Technology Transfer and Innovation, pp. 16-18).

The Passive Mode

The passive mode, also called dissemination mode, is illustrated in Figure 6.6. The most familiar and widely used form of passive technology transfer is the published literature. There is no direct communication or assistance from the originator of the technolo^gy to the producer of finished consumer item. Yet thousands of products are made and consumed from this form of knowledge transfer. Similar forms of passive technology transfer are self-teaching manuals such as television repair manuals and how-to-do-it guides for home repairs.

The Semi-active Mode

In the semi-active mode of echnology transfer the role of technology transfer agent (in addition to self-educat on or self-retrieval of elements of technology transfer) is 'somewhat limited. This is illustrated in Figure 6.7.

The technology transfer agent (consultant or technology expert) screens available pertinent information for product development. Here the role of transfer agent is only that of an interpreter or communicator. He will not actively participate in the application of the technology.

The Active Mode

The active mode technology transfer carries.the process through to an actual demonstration as shown in Figure 6.8. The figure demonstrates various steps involved in the construction of the model or a product from procurement of material to fabrication and assembly. In this mode the technology transfer agent or consultant will be fully involved and acts as a bridge in technology transfer from technology source to entrepreneur or implementing agency.

Horizontal and Vertical Technology Transfer

Horizontal Technology Transfer implies transfer of technology from one. firm to another: Such transfers 'take place generally between the firms located in different countries, mainly due to reasons of competition and maturity or near maturity of technologies. Vertical technology transfer means transfer of technology from an R&D organisation to a firm. Such transfers are mostly within the country and the technologies are new, and may often require further efforts in terms of establishing commercial viability. Such a transfer involves considerable risk.

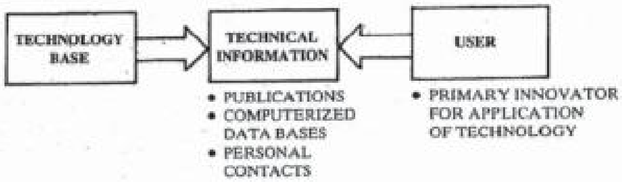

Figure 6.6 : Technology Transfer—Passive Mode

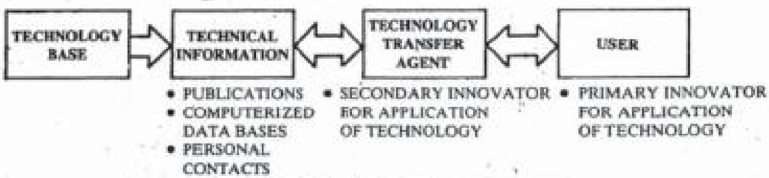

Figure 6.7 : Technology Transfer—Semi-active Mode

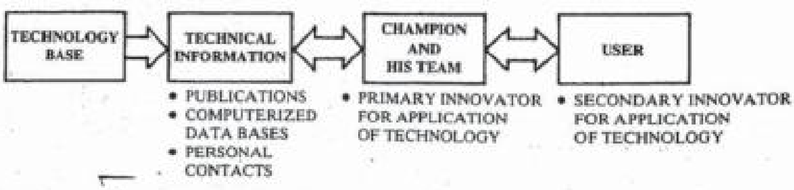

Figure 6.8 : Technology Transfer—Active Mode

6.4 TECHNOLOGY SEARCH STRATEGY

Very large companies have a special department or unit dealing with technology transfer and licensing. Medium and small sized firms have no formal department to take care of technology licensing. A company, big or small, may at one time or other, require transferring technology or import of technology from outside. The process of transferring technology either in' or 'out' is subject to both managerial and other resource limitations. Technology search strategy has to be undertaken by the unit to identify suitable technology within the enterprise or import of technology from outside to maintain growth and profitability of the company.

The market conditions in any country are dynamic and can operate in a very ad hoc manner. It should be a major concern for companies to undertake search strategy to identify suitable projects or components for sustained growth. An effort to find a suitable new product and knowledge of the potential licensor of that product may lead tQ an early decision and successful implementation of the project.

It is useful to define why new products are required, the type of product that is required, its stage of development and whether this product will fit with the existing skills and resources within the firm. The success of seeking a new product will also depend on, among other factors, their technology search strategy and whether the relevant factors are defined and employed at the outset.

A schematic model of this process is shown in Fig. 6.9.

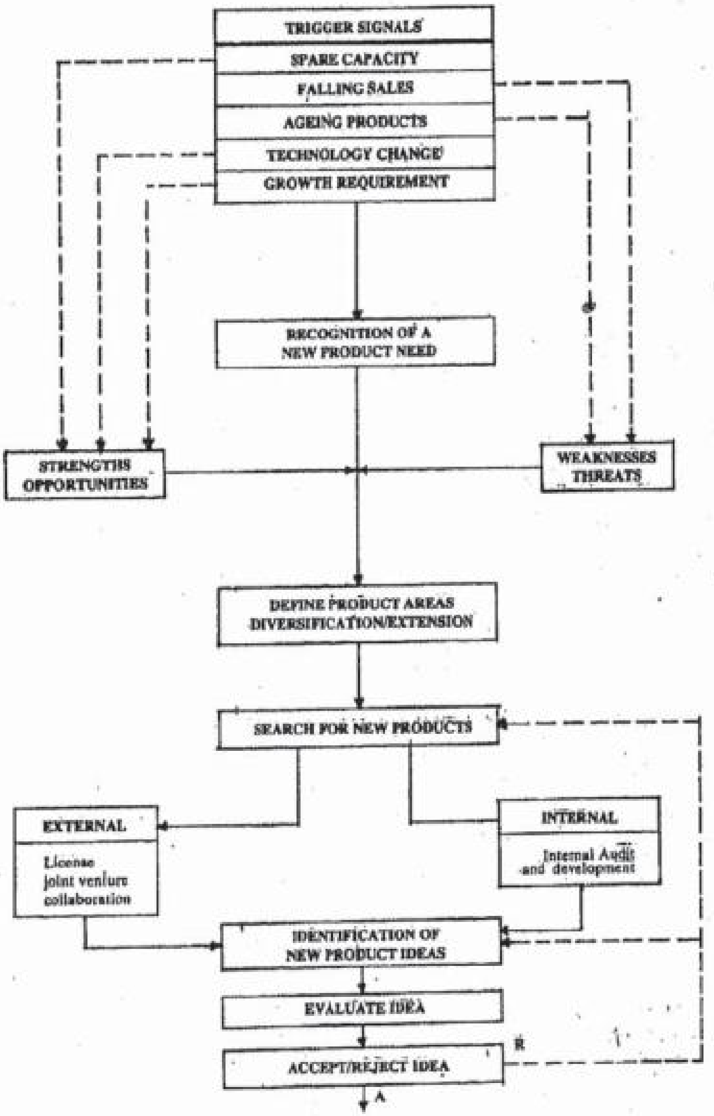

Figure 6.9 : Developing a Search Strategy

An audit of products, citing strengths and weaknesses, may be useful in identifying gaps in the portfolio that could be filled by the use of licensing.

Recognition of Commercially Viable Products

Any search strategy will identify a large number of potential licensing opportunities but many of them will be unsuitable or inappropriate for a particular firm at a particular time. For a firm with small research and development facilities, any product requiring substantial further development before marketing is likely to prove unsuitable as a potential licensing prospect. Products with a known track record, and substantial marketing and production back-up are likely to be least problematical for smaller firms. A perfect license may consist of a product that :

- has good protection in the licensee market.
- is sold under a well-known trade mark.
- requires no changes in the licensee market. • for which there is a substantial demand.
- is subject to an exclusive agreement.

- has a good `fit' with licensee operation.
- is transferred under a `reasonable' technology agreement.
- has assured continued technical and managerial support.

Recognition of commercially viable products is clearly a function of the firm or its consultant. The major advantage of a licensed product over the one produced in-house is that the licensed product might have been tried and tested and found to be successful elsewhere. Hence some of the risks associated with the new product have been reduced to the benefit of the licensee. The major disadvantage is that the technology may be generally matured or even obsolete.

Outward Licensing

The licensor has to develop a search strategy based upon his knowledge of the market and the characteristics of his product, in identifying suitable licensees for his product. Following the search strategy the licensor will need to take into account the type of the licensee firm and its reputation, its market strength and production capabilities before making a decision. Personal empathy with licensee personnel is also an important factor.

Transfer of, technology under a license agreement comprises the culmination of a multi-stage process carried through by both partners to the agreement. Pre-transfer stages can be tabulated as below :

	Licensor		**Licensee**
i)	Marketing strategy defined		Definition of product requirement
ii)	Licence decision	ii)	Evaluation of `In-house' or external development
iii)	Evaluation of Technology	iii)	Decision to licence
iv)	Definition of Technology	iv)	Search for partners
v)	Search of partners	v)	Transfer of technology
vi)	Transfer of technology		

Activity 2

Arrange a meeting with an experienced and knowledgeable person in the Engineering or related division of the organisation with which you have been associated. Gather information on he following and analyse as suggested.

i) How did the organisation go about searching for an appropriate technology acquired in the past?

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ii) What strategy is the organisation proposing to follow for technology which is in the pipeline for acquisition? Is it different in any way from the one followed in the past? *What* reasons have accounted for the difference and why?

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6.5 DIMENSIONS OF TECHNOLOGY TRANSFER

The time and resources required to transfer a given technology depend upon :

- what is actually transferred
- the mode of transfer
- the absorption capabilities of the recipient enterprise
- the capabilities and motivation of the supplier enterprise and
- the technology gap between the supplier and the recipient (Fig. 6.10', Source : Asian Productivity Organisation, Tokyo, 1976).

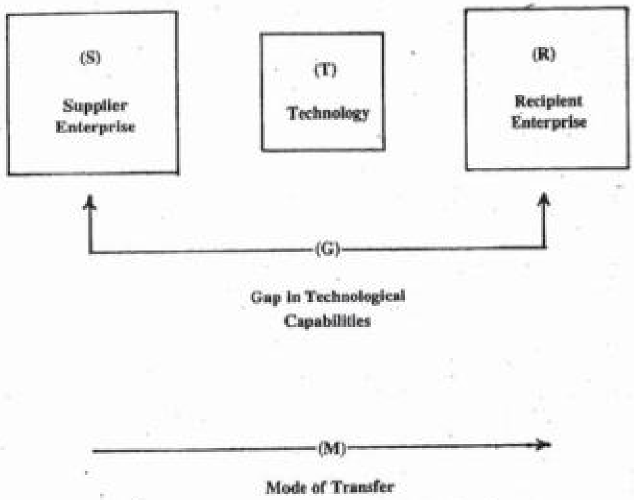

Figure 6.10 : Identification of Technology Gaps

6.6 FEATURES OF TECHNOLOGY PACKAGE

The technology package consists of three principal elements namely, product design, production technique and management systems.

Product design may range from simple items to highly complex (e.g., automotive) parts. **Production techniques** and plant layout include blueprints and flowcharts, formulas and recipes, process sheets, fabrication instructions, tools and fixture designs, operational procedures and material specifications. **Management Systems** consist of various plans, layouts and technical control systems (along with related marketing and financial controls); Included are plant design and layout, quality control and testing, material procurement, inventory control, equipment maintenance and. repair and machine loading techniques.

The three principal categories of technical information or know-how inherent in technological systems are general knowledge, system-specific and firm-specific knowledge. These various categories of knowledge may be in the form of written materials or may be embodied in technical assistance, on-the-job training or built into fabricating or processing equipment.

General Knowledge refers to information common to industry such as blueprint reading, tool and fixture design and fabrication, welding techniques etc.

System Specific Knowledge refers to information and industrial capability within a firm that gives it a competitive advantage over rival firms. This knowledge and know-how may consist of special solutions or procedures to a problem, acquired in the previous manufacturing experience in related product or process fields.

Firm Specific Knowledge differs from system specific in that it cannot be attributed to a particular production item and usually results from the firm's overall activities in such areas as grey-iron casting or their material fields. This technical knowledge or know-how goes beyond the general level possessed b y the industry as a whole.

Activity 3

Describe the elements of the "Technology Package" that might been acquired through the technology transfer process by your organisation or a case that you know of.

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6.7 ROUTES OF TECHNOLOGY TRANSFER

The principal routes of enterprise-to-enterprise technology transfer are :

a) **Licensing or Franchise**
Licensing and Franchise arrangements vary from a complete package of instructions, technical assistance and training to mere permission for the manufacture and sale of a product.

b) **Suppliers of Materials and Parts**
Suppliers of materials and parts are often willing to provide a full range of technical support, information and manufacturing know-how, and they can be as effective in know-how transfer as in industrial licensing arrangements. The manufacturing of colour TV'sets in India is a classic example of this type. The manufacturers did not have a formal technology transfer agreement but had an understanding with the foreign suppliers of materials and components regarding technical assistance in production.

c) **Equipment Supplier**
A variety of technical services are provided by equipment suppliers, including operational and maintenance procedures and even processing know-how (typical in chemical industry). Some technologies are machine based and therefore the know-how is transferred along with supply of plant and equipment.

d) Outright purchase e.g., of turnkey plants or of complete manufacturing and operating specifications, drawings, know-how, performance data and technical assistance.

e) Acquisition of the company or business owning the technology.

f) Joint ventures with the technology owners.

g) Franchising of trademarks and technical, management, and marketing know-how.

h) Combinations and variations of any of the above.

Activity 4

Which route of technology transfer has been generally adopted foa a product in your organisation or that you know of? Discuss the reason as well as merits and demerits.

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6.8 TECHNOLOGY ABSORPTION CAPABILITIES OF RECIPIENT ENTERPRISE

The absorptive capabilities of the recipient enterprise depends upon its resources and capabilities (embodied in technical and managerial skills as well as financial strength) and upon the transfer capabilities of the supplier enterprise. The following are some of the problems encountered by small-to-medium enterprises in technology absorption.

Service facilities : Material testing, heat treatment, instrument calibration, engineering standards and quality control procedures.

Manufacturing : Material standards and specifications, manufacturing processing procedures, formulas on alloys and compounds, fabrication and use of fixtures, jigs, dies and tools, welding techniques, casting and other metallurgical processes and material substitutes.

Equipment : Special equipment designs (heat exchangers, pressure vessels, bearings heating elements) and standardisation of major machine components (gear boxes, machine tools), die casting etc.

Technology absorption aspects are discussed in the next unit.

6.9 COMPETENCE OF KNOW-HOW SUPPLIER

Transfer capabilities and motivation of the enterprise supplying the industrial technology have an important bearing upon the effectiveness and efficiency of technology transfers. The competence of the transfer agents, including their ability to design an easily transferable technology package, is an important factor. The supplier enterprise and its transfer package represent a combination of documentation, training and technical assistance. Motivation of the technology supplier depends largely on the transfer mode and the potential return the supplier hopes to realise from an effective and efficient transplant.

6.10 PRICING OF TECHNOLOGY

In most licensing situations payments have to be made by the licensee to the licensor. The payments represent compensation to the licensor for allowing use of industrial property rights or valuable intellectual property by the licensee and providing necessary technical assistance to enable the licensee to produce as per agreed terms. Generally there is likely to be some financial return for proprietary knowledge or other forms of intellectual property to the licensor. The process by which this return is determined and agreed to by both licensor and licensee, is crucial to the licensing process. It is, however, not an area that is always amenable to the application of scientific rules, since licensing negotiations are subject to human factor, supply and demand conditions in the market and bargaining power of both the partners. In addition, pricing and negotiating in general is subject to the extent of support being available to both buyer and seller.

Categories of Payments

Payments for the technology may be divided into three broad categories, althoughin practice an agreement may involve a combination of all three : lump sum payment, royalties and fees.

Lump sum Payment : Lump sum payments, by definition, are calculated in advance, though the agreed sum may be paid in instalments. This method maybe appropriate where it is desired to obtain the technology by outright purchase. It may also be a means of obtaining the data on a patented process. Traditional reasons for down payment or lump sum payments are as follows :

- Down payment is a transfer cost representing the specific costs borne by the licensor to prepare a "technology package" for the licensee. Costs could arise from preparing drawings, specification lists, operating manuals, on-site training of personnel etc.
- Down payment acts as a surety, in case licensee defaults on the term royalties, delays in business operations, fails to go into operation after receipt of know-how or undergoes liquidation. By down payment the licensor reduces the risk of surrendering valuable technology.
- It is an advance collection of minimum royalties on estimated turnover of the licensor.
- The licensor may not be in a position to verify licensee's accounts and thus prefers a one time transfer fee.
- The licensed product may be sold internally in the enterprise 'and detailed sales/production records may not be maintained for such sales.

The economic, legal and regulatory environment of the country of the licensee may also influence the collection of lump sum payments. These include stability of national currency or that of exchange rates, regulatory policies of the host country, different levels of taxation etc.

Royalties

Payments are made for the use of all forms of industrial property rights, the ownership rights of which are established by national statutory law (patent', trade mark, copyright),'civil law (trade secrets), or international consensus (know-how). As a consequence, payments arise in the licensing of industrial property rights because the licensee derives protected benefits from its use. Royalty can be considered a lease payment, not an outright payment.

Royalties may be paid as a percentage of sales value, whether the technology is in the form of know-how or the use of patented equipment/process of production. The ex-factory value of total sale is frequently the basis of calculations. Alternatively, the royalty may be based on the gross value of production.

The rate of royalty may be related to. the net value of production. Whether the royalty is based on sales or value added, payments will increase in an inflationary situation, irrespective of the contribution of technology acquired.

Fees

Fee for technology which may be remunerated specifically include training, whether in the licensor's or in the licensee's works, the position for technical experts required to introduce the technology and fee for expert assisTance in the setting up of associated research and development, design and engineering services. Any fees payable for the management of the plant, purchasing of inputs, etc. are a separate matter, to be distinguished from those of technology fees. Fees related to foreign personnel should be calculated on the number of hours of such services which are agreed upon.
The three ways of payment are three alternatives. In the end, it is the total, payment to be made by the licensee by whatever means and over whatever period, that matters

to both the parties.

Factors Affecting Royalty Rates

In any negotiation for technology transfer, both parties will arrive at their 'reservation' price by some assessment of the costs and benefits they both derive from trade, so that the financial benefits are acceptable to each side. This determines the absolute range over which the price can be negotiated. The process of finalising a specific price depends on the bargaining strength of the two parties, as well as their negotiating skills and general attitude towards risk and uncertainty. These factors will. depend on the nature of the intellectual property to be exchanged. I Tables 6:1 and 6.2 present the key factors affecting the alternative pricing of intellectual property, first from the point of view of the licensor and second,, from that of the licensee.

From Tables 6.1 and 6.2 it is apparent that various factors on the cost and benefit side of the equation can affect the pricing of a licence and fixing royalty rates. At the outset, the royalty level will be based on an assessment of the respective valuations of both licensor and licensee of these factions. However, that merely sets a maximum and a minimum royalty rate that both would find acceptable. Once it has been established that there is scope for trade, the rest of the pricing decision revolves around the risk preference and bargaining power of, the two parties. Figure 6.11 illustrates this bargaining range. The essence of this table is again to emphasise the existent of an overlapping range within which other factors play an important role.

Table 6.1 : Factors Underlying Licensor Royalty Negotiations

FACTOR / TYPE OF PROPERTY	COSTS	BENEFITS	TIME	RISK	BARGAINING POWER
PATENTS	Cost of development Cost of filing, maintaining and enforcing the patent Costs of transfer in terms of people, materials, time etc. Revenues lost through not directly exporting or working the patent.	Royalty payments Grant backs of developmental knowledge Control of competition	Long agreement (upto 20 years	Patent infringed Audit of licensees sales is difficult Setting up competition Licensee uses your property to develop his own new products faster than your own.	Tightness of patent Ability to enforce Distinctive nature of product process Existence of other complementary property Ability to directly export or directly invest
KNOW-HOW	No filing and maintenance cost	Same	Much shorter length of agreement	Secrecy problem difficult to control	Same
COPYRIGHT AND REGISTERED DESIGN	No filing and maintenance costs. No development cost.	Same	Variable time	Enforcement of copyright more difficult	Same
TRADEMARK	No filing and maintenance cost. No development cost.	Same	Longer time period	Poor quality products under your trademark	Critical in consumer markets

Table 6.2 : Factors Underlying Licensee Royalty Negotiations

TYPE OF PROPERTY / FACTOR	COSTS	BENEFITS	TIME	RISK	BARGAINING POWER
PATENTS	Royalty fee Alternative costs of in-house development Limitation on markets Costs of inward transfer Licensed product may make own products obsolete	Rapid Introduction of product Gross margin of licensed products Keeping company together in times of recession Basis for future technical development	Long period of agreement Speed of introduction	Patent may be infringed Product may be made obsolete Limitation of markets; he can compete in on a 'monopoly' basis Changes in the law of restrictive practice	Size of market penetration can provide for licensor Barriers to export for licensor Local market knowledge an advantage
KNOW-HOW	Inward transfer may be more difficult	Access to secret technology other firm will not know about	Can take longer to incorporate than patent Shorter agreement	Firm may be locked into a long-term agreement after secret is widely known	No protection other than secrecy for licensor
COPYRIGHT	No costs of inward transfer	The only way of obtaining some sort of property	Long time period	Easy to break copyright but difficult to enforce and police	Very little for some 'unique' property
TRADEMARK	No costs of inwird transfer	Instant market penetration and brand loyalty	Long time period	Trademark is devalued by poor performance of other trademark holders	Very little for some 'unique' property

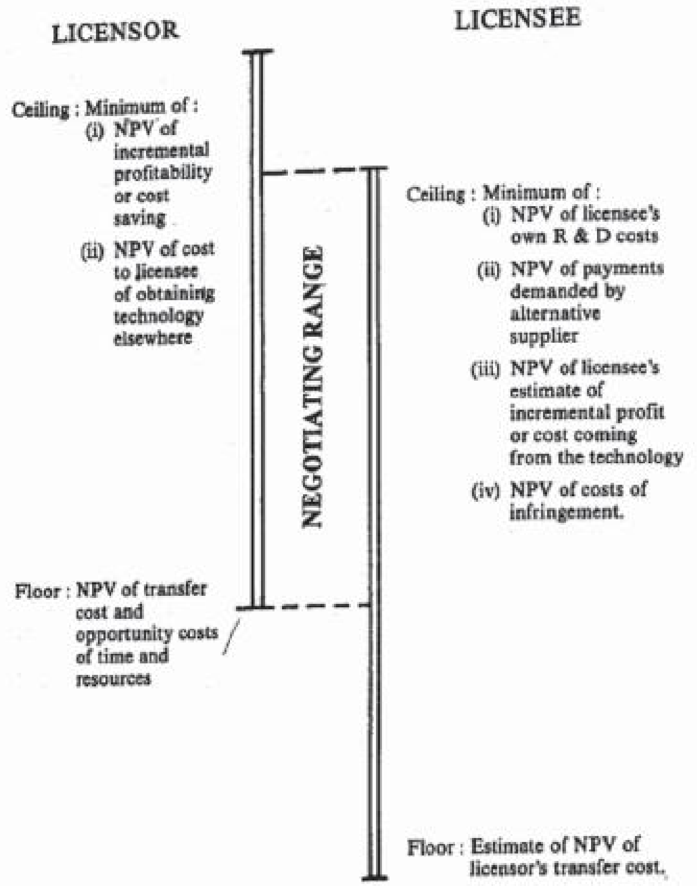

Figure 6.11 : Configuration of Bargaining Ranges

Commonly Used Intellectual Pricing Methods

Some of the more commonly used royalty rate development models are discussed, highlighting their primary deficiencies.

The "25 Per cent" Rule

Under; this method royalty is calculated at 25 per cent of the gross profit, before taxes, from the enterprise operations in which the licensed intellectual property is used. At best this method of royalty determination is crude. .

Gross profit based upon "generally accepted accounting principles" concept includes the direct costs of production. These include raw material cost, direct labour, manufacturing expenses and depreciation expenses. All of the costs and ,expenses associated with conversion of raw materials into a final product or service are included. Since this is most likely to be the area of greatest contribution from intellectual property,. consideration of the amount of gross profit in setting a royalty is reasonable but it fails to take into account the final profitability that is ultimately realised with the licensed property. Absent from the analysis are setting, administrative and general overhead expenses.

Intellectual property that is part of a product or service which requires little marketing, advertising and selling efforCis far more valuable than a product based upon intellectual property that requires the use of national advertising and a highly compensated sales, personnel. Two patented products may cost the same amount to' produce and yield the same amount of gross profit, yet one of the products may require extensive and continuing sales support while the other may not. The added costs of extensive and continuing sales efforts make the first product less profitable to the licensee. While the two products may, have the same gross profit, it is very unlikely that they would command the same royalty.

The 25 per cent rule also fails to consider the other key royalty determinants of risk and fair rates of return on investment. The "25 per cent rule" is not even useful as a general guide upon which to begin negotiations.

Industrial Norms

The industry norms method focuses upon the rates that others are charging for intellectual property licensed within the same industry. Investment risks, net profits, market size, growth potential and complementary asset requirements are all absent from direct consideration. The use of industry norms-places total reliance upon the ability of others to correctly consider and interpret the many factors affecting royalties.

Changing economic conditions along with changing investment rate of return requirements also are absent from consideration when using industry norms. Even if an industry norms royalty was a fair rate of return at the time it was established, there is no guarantee that it is still valid after some years. Value, economic conditions, rate of return and all of the other factors that derive a fair royalty have dynamic properties. They constantly change and so must their underlying analysis that establishes royalties. Use of established industry norms fails to reflect changing conditions.

Return on R&D Costs

Basing a reasonable royalty on the amount that was spent on development of the intellectual property could be terribly misleading. The amount spent in the development is rarely equal to the value of the property. The millions of rupees spent on research relating atomic energy, space, defence etc. may yield to the Indian Government very little intellectual property.

A proper royalty should provide a fair return on the value of the asset regardless of the costs incurred in its development. The underlying value of intellectual property is founded upon the amount of future economic benefits. Factors that can limit the benefits include the market potential, the sensitivity of profits to production costs, the period of time over which benefits will be enjoyed and the many other economic factors that were discussed. The development costs do not reflect these factors in any form. Basing a royalty on development costs can completely miss the goal of obtaining a fair return on a valuable asset.

Return on Sales

Royalty based upon a percentage of revenues' sales has several primary weaknesses. The first difficulty is the determination of the proper allocation of the profits between the licensor and the licensee. Another area of weakness is the lack of consideration for the value of the intellectual property that is invested in the enterprise as well as a lack of consideration for the value of the complementary monetary and tangible assets that are invested. Finally, this method fails to consider the relative investment risk associated with the intellectual property.

There is no rigid formula for determining the price of intellectual property and thus estimates vary from case to case. The price of know-how/intellectual property normally ranges between 2% to 10% of either the plant and equipment cost or projected turnover production of the unit for a period of 5 years. However, the price would depend, on the estimates of opportunity value and "what the market can bear" Besides, the realisation of price could be. divided between lump sum amount and recurring royalty payments. Although it would be in the interest of licensor to realise as much of the price as is possible through lump sum payment, the licensee's interest would be to pay the price only through recurring royalty based on production. Thus, balance has to be struck between these two components.

6.11 TECHNOLOGY TRANSFER AGREEMENTS

A Technology Transfer Agreement is a contract between the licensor and licensee, detailing the scope of services and terms and conditions from both sides. Drafting of this agreement is often a highly complex job requiring considerable skill and experience, since the interests of the two parties may sometimes be conflicting. However, the obligations of the licensor and licensee may broadly relate to the following

Obligations of the licensor

a) Supply of the technical means
b) Technical assistance to the staff of the licensee
c) Provision as to the results and consequences of non-satisfaction of the guarantees.
d) Exclusive and non-exclusive rights
e) Preservation of secrecy
f) Title of the licensor
g),) eriod of agreement
h) Force majore
i) Intellectual property rights
j) Updated technologies and improvements
k) Technicl information
l) Training
m) Help in marketing and exports
n) Settle n_1 ent of legal disputes
o) Access to R&D

Obligations of the licensee

a) Payment
b) Secrecy
c) use of the know-how
d) Minimum output
e) Maintaining specified quality or standard
f) Adequate technical and managerial standards and facilities
g) Focal facilities for the experts/staff of the licensor
h) Access to the factory premises as required
i) Legal disputes

Activity 5

Are you aware of any agreement made between the two firms? If so , what were its salient features and how was it implemented?

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There-have been several studies regarding the technology transfer agreement at national and international levels, and even model agreements have been evolved by the UN and national governments in several countries including India. However, these remain only guidelines, and technology transfer is more an expression of mutual faith rather than a legal issue.

6.12 CODE OF CONDUCT FOR TECHNOLOGY TRANSFER

It is widely felt that firms including transnational corporations (TNCs) in developed countries exploit firms in developing countries while transferring technologies, and unfair practices prevail to the disadvantage of the latter. The United Nations Conference on Technology and Development (UNCTAD) has been making attempts for the last more than a decade, to formulate a commonly accepted code of conduct, taking into account the interests of all the parties concerned. However, this effort has so far not succeeded due to differences between the North and the South, and several issues such as laws of the land, restrictive practices, etc. Nonetheless, the documents that have'been prepared so far have served as guidelines and have created awareness about the various issues which need to be examined while entering into technology transfer agreements.

6.13 GOVERNMENT INITIATIVE AND TECHNOLOGY TRANSFER

Many Governments in advanced countries encourage the introduction/import of new technologies to help or generate business development and economic growth. In countries, such as Sweden, Japan, South Korea etc., the Governments have instituted programmes of technology search whereby local companies and consultants are encouraged to set up networks of foreign contacts in other advanced countries to identify innovative products that could be made under licence in their country. These initiatives seek to use importation of technology to rejuvenate industries and initiate new product development. The innovation and economic growth is ultimately bound to follow the path of simulating R&D spending as a way to promote greater product innovation. These countries have excelled in technology innovation and in many cases improved upon the technology. Japan has become a major supplier of sophisticated technology to developing and developed countries.

Government Regulations in Developing Countries

Indiscriminate entry of inappropriate technologies will go against the declared national development objectives/priorities. It is in this context that most of the developing countries have established effective official mechanisms for determining the type of technology suitable to particular circumstances of their economies, and have developed systems and procedures for collection of information and data on technologies so as to strengthen their negotiating strength with the technology suppliers.

The scope of these regulations covers a wide spectrum of issues. All of these include the establishment of a national registry incharge of screening and authorising a particular technological transaction. They define the transaction to be controlled by the registry. Special requirements or criteria like contribution to domestic technological capabilities, training local 'personnel and processing of domestic resources etc. are generally prescribed. Another important aspect relates to policies restricting the direct cost of technology transactions; i.e., a ceiling on remittance of royalties, control of payments for unused patents, direction of the agreement, control on excessive prices etc. The regulatory system does not generally encourage indigenous development and the production is based on second or third generation technologies.

Structure for Licensing Service

The use of licensing to help local development requires four key inputs

i) Information on licensing opportunities
ii) A database on potential client companies
iii) Technical personnel to interpret both the requirements of client firms and the offerings of potential licensors.

(i) and (ii) could partly be provided by recourse to existing resources of a company. Ministry of Science and Technology and a few other ministries have established specialised departments for creation of database. The information is made available to the enterprise to supplement their own information systems.

In India, most of the technologies are transferred from industrially advanced countries through various routes, the more popular being the route through licensing arrangements. There have been over. 12,000 foreign collaborations in the past, 80% of which are from eight developed countries such as USA, Japan, West Germany, France, and Italy. Some of these foreign collaborations had equity participation also, the foreign investments being of the order of Rs. 500 crores per year. There are several instances of transfer of technology from R&D organisations to industry, mostly in areas of low technologies or technologies relevant to Indian conditions. The CSIR has played a major role in this respect, while technologies from Defence R&D, Department of Space, Department Atomic Energy, etc. are also now being transferred to industry. There are very few instances of transfer of technology from one firm to another. In some areas such as chemicals & pharmaceuticals, construction, textiles, steel, hotels, cement and management, India has even exported "technologies and services to other developing countries through licensing arrangements or contractual arrangements or joint ventures. Government is now paying greater attention to exports of technologies and services.

Indian Experience

The Industrial Policy Resolution of 1948 and the Industrial Policy of 1956 provided the basis for government policy for foreign investment and also in making available to the country the Scientific, technical and industrial knowledge. The transfer of technology was conceived to be a part of the flow of foreign capital and accompanying the technical collaboration.

In 1961 selective foreign private investment and foreign collaboration were introduced. The Policy was to attract foreign capital in those fields in which the country needed development'in pursuance of the plan targets... economic development also for generation of employment..

The policy towards foreign collaboration was further liberalised in 1970 for bridging technological gaps that existed in several sectors of industry. The Industrial Policy Statement of 1977 took note of continued inflow of technology in sophisticated areas. The policy statement gave preference to outright purchase of best available technology and then adopting it to meet the needs of the country.
In the Industrial Statement of 1980, induction of advanced technology was favoured for encouraging exports and production of quality products at competitive prices.

Technology Policy Statement of 1983 was directed toward technological self-reliance. In the acquisition of technology, consideration was given to the choice and sources of alternative means of acquiring it, its role in meeting a major need of the sector, selection and relevance of the product, etc.

The Government of India in its Policy Statement of 1991 liberalised most of the restrictions in technology import. The policy is aimed at encouraging foreign investment upto 100 per cent in most of the sectors with a view to promote exports competition in Indian industry and production of better quality products. The regulatory procedures have been abolished with respect to many industrial sectors to allow free flow of technology.

6.14 SUMMARY AND CONCLUSION

Technology transfer is a process or activity to acquire technologies and is not a mere transfer of know-how from one person to another, although know-how transfer is an important part in it. There are various models regarding technology transfer. What model will be used would vary from case to case. We discussed various modes of technology transfer. In technology transfer, it is generally expected that transfer activity wouid stimulate economic and technological development in the economy.

The industrial enterprise should have a continued growth. The growth comes either from internal technology or technology acquired from outside. A technology search strategy is important for technology transfer and is part and parcel of the corporate plan of an enterprise. A company may select appropriate technology/product for manufacture and sign a technology transfer agreement with the licensor. But it should have a suitable R&D infrastructure for absorption and upgradation of the technology. An assessment of licensor's credibility and capacity tg transfer the technology would be helpful in ensuring success of the project.

There are various factors which affect the pricing process in licensing. There are various analytical frameworks based on which the licence negotiations can be set.

One of these is to establish a framework of the various terms/matters of the agreement and evaluate licensor/licensee bargaining responses relating to them. However, these can only be regarded as aids to decision making and not as substitutes, since licensing negotiations depend very much on human factors. In licensing, as in many other aspects of business, skilled negotiations are a vital factor in business success.

The objective of technology transfer is to enlarge business opportunities and to maximise profits for the enterprise. The determination of a fair price for technology is important. The different methods of compensation for a technology package *were* discussed along with factors affecting payment.
In advanced countries market forces dictate technology development and technology inputs. There is relatively unrestricted flow of technology. The experiences of developing countries vary. South Korea has emerged as one of the industrialised developing countries with active support and encouragement provided by its Government. In many developing countries, the Government regulations restrict technology transfer. These restrictions may retard development of industry and hence the economic growth of the country. A country should have a well organised information and data bank system on national and international technology. The necessary information should be made available to industry so that the latter can select the best and competitive technology for induction.

Advanced countries and transnational corporations generally follow restrictive practices while transferring technology to developing countries, mainly, because the latter are in a weak bargaining position. UNCTAD - a UN Agency - has been making efforts for about a decade to evolve a `code of conduct' for `Transfer of Technology' to ensure fair returns to all parties concerned but has not met with much success so far.

6.15 KEY WORDS

Licensor : Seller or supplier of technology.

Licensee : Purchaser or recipient of technology.

Technology Transfer : Transfer of knowledge generally through purchase of technology for use.

Bridging agencies : Government departments and promotional organisations acting as support agencies for development and use of technology.

Active Mode : Assisting the potential use of technology in transferring and in the application of technology.

Technology transfer agent : Someone who will listen to the user's problems and advise on the appropriate technology, e.g., a consultant.

Search Strategy : Strategy to find new product/project suitable for license in accordance with overall business strategy.

Resources : Financial, managerial, technical resources and material available for implementing the project.

Technology package : A package of technology components including detailed procedures and instructions for implementing the project.

Production techniques : Manufacturing procedure for a product

Franchise : Giving of licensing rights by the technology owner or supplier to the licensee to manufacture a given product.

Adoption of Technology : Involves carrying out required changes/modifications in the technology/design acquired from licensor to enable the use of local raw materials and purchase items.

Royalty : Financial compensation payable to licensor for use of intellectual property rights, as a percentage of turnover or profits, for a limited period. **Lump**

sum payment : One time payment for use of know-how or technology.

NPV : Net present value of money.

Intellectual property : Knowledge, know-how or technology.

Intellectual fee : Financial compensation payable for use of knowledge, know-how or technology.

Regulations : Rules and procedures introduced by the government.

Data Bank : Collection, storing, processing and dissemination of technical information.

Information Service : Technical data made available to the user.

Licence Agreement : Contractual agreement to acquire technology from outside agency,

Code of Conduct for Transfer of Technology : Fair code or guidelines and norms beneficial to the licensor and licensee.

6.16 SELF-ASSESSMENT QUESTIONS

1. What is Technology Transfer? What is the impact of technology transfer on industries and economic development of a country?
2. Discuss the role of technology transfer and its key factors, as applicable to an enterprise.
3. Why should we regard technology as a strategic element and a strategic resource?
4. Differentiate between various Models of Technology Transfer.
5. What are the modes of technology transfer? What mode of technology transfer is normally followed in developing countries? Give an example that you know of regarding modes o f technology transfer in India.
6. Explain Technology Search Strategy with reference to technology transfer. How is a Technology Search Strategy developed for an enterprise?
7. Give examples of Positive and Active modes of technology transfer.
8. Why should a company go in for technology transfer to manufacture a new product or implementing a new project?
9. Discuss various routes available for technology transfer.
10. *How* does an enterprise select suitable technology for implementation?
11. Discuss the merits and demerits of in-house technology development vis-a-vis import of technology from outside.
12. "The credibility and competence of the licensee are important for effective

transfer of technology." Discuss. Support the statement through an example that you are aware of.

13. Do you agree that pricing of technology is an important factor in technology transfer? If so, Why? What are the considerations and norms for pricing a particular technology? Give an example.
14. What is a "technology package" and what are its essential features?
15. Discuss the role of "intellectual property" as applied to technology transfer.
16. What are the methods of payment for a technology?
17. Discuss the merits and demerits of different methods of pricing a technology. What, in your view, is the best method?
18. What are the factors to be considered while entering into a technology transfer.
19. For a licensee, which form of payment do you suggest for a technology-one time lump sum or royalty spread over a period of time? Give your reasons.
20. Discuss advantages and disadvantages of liberalised import of technology.
21. "Governmental regulations in India have retarded industrial growth in the country." Comment.
23. Would you suggest free supply of (data bank) information to all as a service?
24. Discuss the obligations of licensor and licensee in a Technology Transfer Agreement.
25. What do you understand by Code of Conduct for Transfer of Technology?

6.17 FURTHER READINGS

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Uttar Pradesh
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MBA-4.4
Technology Management

Block

3

TECHNOLOGY ABSORPTION AND DIFFUSION

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3LOCK 3 TECHNOLOGY ABSORPTION AND DIFFUSION

Block 3 deals with issues related to Technology Absorption, Assessment and Evaluation, and Diffusion. The technology import by itself cannot bring about the greatest advantage to the nation or to the enterprise unless it is followed by intensive and effective absorption efforts. Similarly, the technology generated or developed in the government or industrial laboratories must be diffused at the widest possible spectrum in order to realise greatest returns on investment and to benefit the largest numbers in society.

This block has three units.

Unit 7 deals with matters related to **Technology Absorption, Adaptation and Improvement.** The unit begins by explaining the scope of technology package and enumerates the various areas for which the Indian manufacturers generally depend on foreign know-how. For any industry to become really competitive, it is necessary for it to aim at higher efficiency, improved productivity and operations at the lowest possible cost. What problems or constraints the Indian industry, in general, faces in this context are explained. The unit then describes the magnitude of and trends in the import of technology into India. With this background prepared, the Indian experience relating to absorption efforts is discussed. The suggestions and views of the industry in this respect are also outlined. What areas in this context need further attention are discussed. International experiences with regard to absorption and the initiatives taken by the Government of India for augmenting and accelerating technology absorption are dealt with. Lastly, benefits of technology absorption are listed and future thrusts needed in the broad area of absorption are indicated.

Unit 8 looks at **Technology Assessment (TA) and Evaluation**. The terms Technology Assessment and Technology Evaluation are defined and distinguished. The origin, definitions and scope of TA are discussed. The methodology of conducting a TA study and the various stages through which the whole exercise may have to pass are briefly dealt with. How should TA activity be organised or managed is also explained? The key-words for success of a TA study are outlined. The background of technology evaluation is given. What could be the various bases or parameters on which a particular technology could be evaluated are discussed with examples.

Unit 9 deals with **Diffusion of Technology.** The concept and importance of diffusion are explained. Various perspectives on diffusion are provided. Major diffusion activities ranging from individual action to commercialisation and diffusion on a wide scale are discussed. The Unit then focuses on how to develop a diffusion strategy. In other words, what should be the ingredients of an effective diffusion strategy are described. The Appendix to this unit briefly discusses a diffusion model. This model as an illustration will be of interest to those of you who would like to persue this area further for study.

UNIT 7 ABSORPTION

Objectives

After studying this, you will be able to understand:

- Indian industrial and technological scenario and trends in industrial R&D, and technological dependence.
- to Concepts and constraints in technology absorption and industry's view on technology absorption.
- Management of technology absorption and Government initiatives.
- Benefits and future thrust in technology absorption.

Structure

7.1 INTRODUCTION

It was mentioned in the previous unit that one of the ways to acquire technology is to bty/obtain it from sources within or outside the country. Once a technology is imported from another country, it needs to be absorbed and updated in accordance with the local requirements. Foreign technology may have been developed keeping in view different parameters relating to scale of production, raw materials and components, quality standards, costs, levels and types of production techniques, maintenance requirements, social aspects including environmental and pollution aspects, employment, etc. It is common in many developing countries (such as South Korea, Taiwan, Thailand, Indonesia, India, Pakistan, Sri Lanka, Bangladesh, Philippines and including our own country) to import technology as a package. Several of these countries have developed indigenous R&D capabilities of varying order to absorb and upgrade the imported technologies, and to achieve technological self-reliance. While some countries, such as South Korea, Taiwan and Singapore have absorbed technologies predominantly for exports, India has done so predominantly for local markets.

The concept of technology absorption differs from country to country, and even from firm to firm. In India, absorption is generally considered as the capability to reproduce or manufacture products according to the "know-how" supplied by the licensor of technology, without really understanding the "know-why" of the technology In a country like South Korea, know-why exercises to understand the "black-box" of technology have been emphasised at the firm level without which exports are difficult.

Our attempt in this unit is to highlight the need for technology absorption at the firm level in India, and the measures being taken to encourage absorption efforts. In fact, there are only a few countries which have attempted to provide incentives to industry to undertake technology absorption exercises, with a view to reducing imports and enhancing exports. India is one of them.

7.2 TECHNOLOGY PACKAGE AND TECHNOLOGICAL DEPENDENCE

Technology from abroad is acquired by Indian industry in the form of hardware, software and related services. In some instances, it could be only for using foreign brand names. It could be for a grass-root project or for further technological requirements of an existing plant, or for modernisation or enhancement of a product capability. A foreign technology package may consist of all or any of the aspects, such as product design, process or production know-how, systems engineering, application information, tailor-made equipments and/or their designs, technical services regarding maintenance/safety/continued improvements/international experiences, etc.

Technological dependence on foreign know-how can be in any of the following areas such as:

- Product designs/standards/specifications
- Know-how for assembly of products - Licensing for the use of patents/trade marks
- Process know-how designs and basic engineering, detailed engineering, production technology
- Quality control, safety, pollution control and continued assistance in improvements of technology used in the existing manufacturing facilities
- Supplies of hardware and. proprietary equipments and their designs - Back-up assistance in guarantees, checking up drawings, etc.
- Use of foreign experts and training abroad of Indian personnel
- Operating know-how related to imported production equipments
- Pre-production activities like feasibility studies, project engineering on management, assistance in procurement of capital goods and raw materials as well as components, erection and commissioning, assistance in executing contracts, marketing etc.

7.3 TERMINOLOGY AND CONCEPTS IN TECHNOLOGY ABSORPTION

In discussing the broad issues on technology absorption, adaptation and upgradation, it will be desirable to distinguish the following terminology, and the related concepts.

Adoption

Adoption of technology is a process under which the various features of the technology which is the subject of transfer are suitably modified, changed or altered keeping in view the needs of the buyer. In other words, the needs of the buyer of technology get crystallized and the supplier makes suitable modifications in the technology being supplied so that it conforms, as far as possible, to the requirements of the buyer. This in essence would mean that a foreign technology is scaled up or down or modified where necessary, by the supplier in accordance with the requirements of the buyer of technology. Such `adopted' features, are finalized as a part of the technology package.

Adaptation

Adaptation of technology is a phase that takes place after a technology has been adopted and put to use in production activities/facilities. During this stage, a number of alterations and modifications to suit the indigenous conditions are made and they may relate to the use of raw materials/components manufactured, practical difficulties in down scaling etc. Thus, the particular plant in India could gear itself up to meet the desired, capacity, production, product quality and other related aspects, as planned. The adaptation exercise covers both product modifications as well as production technology changes, using indigenous skills and facilities as well as local materials.

Absorption

Technology is said to be absorbed if it is fully understood, so that it is in a position to be further optimised and upgraded.' Technology absorption involves `Know-why' exercises, basic investigations into the product and/or process and/or systems. This will require `unpackaging' of a technology package. To avoid further dependence, technology absorption requires R&D projects in know-why, optimisation and improvement of product/process/systems and related equipments. Such efforts encompass design investigations, alternate raw materials/components, modifications to suit Indian requirements, etc. Successful projects in these areas will lead to achieving technology absorption capabilities.

Optimisation

After understanding the relevant features of technology, further exercises in `removing rough edges' through R&D and value engineering to effect savings in the use of material and energy consumption, etc. both in product and processes constitute `optimisation' of technology.

Improvement and Upgradation

Capability in technology absorption and optimisation can lead to further exercises in improving the existing products and processes by R&D efforts of industry and other associated research organisations. This will enable industry to meet the changes in technology of the product or processes. Technology upgradation exercises. lead to industry's efforts in extending its know-why capability to a higher range of products or in upscaling the existing process/production technology or manufacturing equipment.

The role of technology absorption in the implementation of a project is shown in Figure 7.1. It will be seen that Technology Absorption activity is taken up only after a project is executed through acquired technology or when the company diversifies or faces threats from market forces to update its products or processes. Figures 7.2 and 7.3 explain the process of "know-why" arising out of imported "know-how". "Know-why" exercises lead to better understanding of the basics or principles involved in the design and production of a product/process which enables an organisation to develop or build technological capabilities for further improvements.

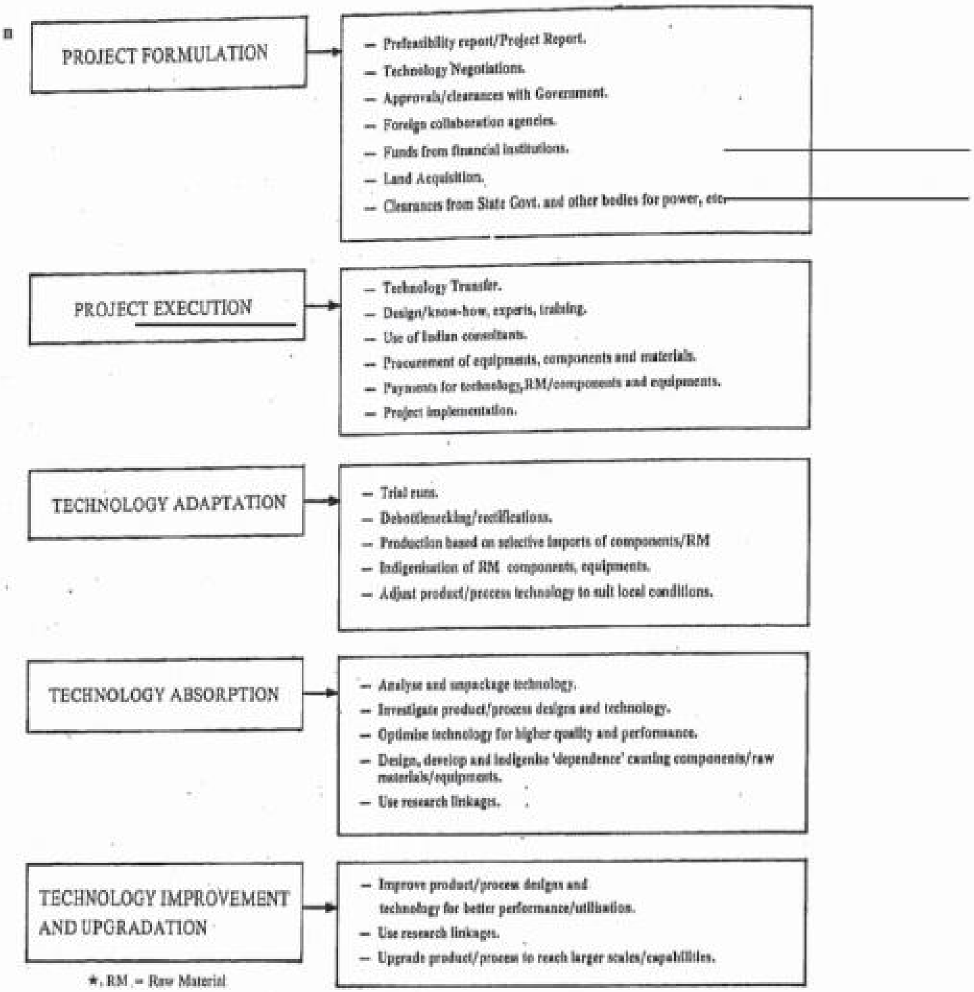

Figure 7.1 : Project Implementation and Technology Absorption.

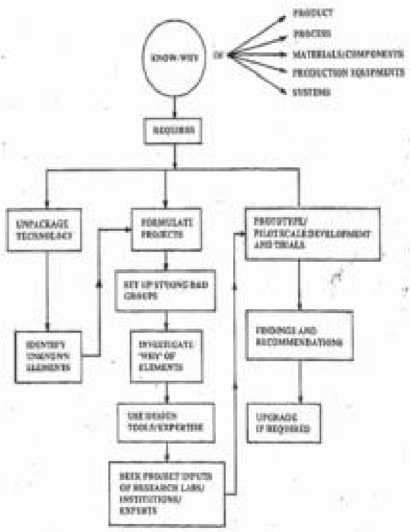

Figure 7.2 : 'Know-Why' of 'What' and 'How'.

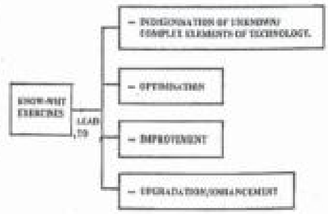

Figure 7.3 : Use of 'Know-Why'.

Activity1

Various concepts in relation to technology absorption have been described in the above section. Under what categories, you would like to place the activities undertaken by your organisation in relation to the technology acquisition and absorption (you may perhaps like to discuss this matter with a knowledgeable executive in your organisation).

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7.4 CONSTRAINTS IN TECHNOLOGY ABSORPTION

Improved productivity and quality as well as reduced costs lead to higher efficiency in industrial operations. In labour intensive industries, these could be achieved from optimum man/machine utilisation, lower overheads, use of versatile machines and quality control measures and industrial engineering techniques. In capital intensive industries involving sophisticated operations to manufacture products which are in continuous demand or which command large markets, these can be achieved by higher automation and by organising the operations on larger scale. In hazardous industries, safety and pollution control measures necessitate higher capital investments in sophisticated equipment based on latest technologies.

The following factors are important in achieving higher productivity, quality and reduced costs:

a) Optimum utilisation of capital equipments to bring about maximum production leading to better capital-output ratio.
b) Adequate investments for quality control, material and energy conservation/recovery, elimination of hazards which would necessitate use of sophisticated equipments.
c) Minimum economic scale of production, particularly in industries where scale factor is important in optimising the operations, especially if in larger quantity of critical production equipment is employed.
d) Targeting and achieving; international levels of performance and operating parameters.

These invariably require use of contemporary technologies needing larger capital investments, and/or accompanied by sizeable domestic demands and satisfactory absorption of technology. In scale sensitive industries, lower the scale of operation, lesser is the level of technology. `Level of technology is also reflected by the use of less productive and sometimes second-hand machinery from abroad. In mass consumption industries such as petrochemicals, man-made fibres, organic chemicals, electronic components, etc. lower the initial installed capacity, lesser is the technological level. In such cases modernisation/R&D costs would be heavy in order to jump to the next generation of technology.

Some of the major constraints in absorption of technology are:

- Choice and use of imported technology by.most Indian industries have not been at international levels. This is an important factor while establishing scale sensitive high technology industries.
- The demand of products in our country whose production is influenced by scale factors of latest technologies is generally not very large, presently these are being met by a number of units of sub-optimal sizes as compared to international levels. This constraint increases the gaps to be bridged through technology absorption.

Industry would not be in a position either to invest similar R&D resources in comparison with international units, or even to improve the products/processes. Expanding the existing units and establishing new units with larger capacities tend to minimize this gap.

- In general, industry has not given adequate attention to absorption of technology, in such cases, the firms have usually approached the collaborators once again for renewal of earlier agreements or for new collaborations for improved or new products and processes. There are instances where existing items made with marginal process or product improvements have continued to be supplied even after extensions of collaborations. In the absence of a competitive domestic market, or where industrial users are dictated by equipments/products based on imported technologies, the inherent tendency to supply the same product has continued, till the users' requirements change or substantial imports of a new product take place. The possibility of continued access to improved technology through further collaboration involving only nominal costs (in any case, not very high payments) and assured markets have desisted many Indian firms from channelling adequate resources for absorption and improvement of imported technology. In scale-sensitive technologies, technology gaps have increased because of inadequate absorption of existing technologies.

7.5 TECHNOLOGY IMPORT IN INDIA

Since independence, Indian industry. has registered impressive growth in producing a variety of goods ranging from primary products to intermediate and consumer goods. A strong capital goods base has been established. A major part of industrial production has been contributed by small and medium enterprises. The core sectors such as power, fertilisers, coal, telecommunication, cement have all grown at a faster pace. Much of this industrial production has been attributed to imports of technology and related equipment. It has been estimated that out of an industrial production in 1988-89 of over Rs. 200 thousand crore, about Rs. 80-90 thousand crore is based on imported technology, out of which about Rs. 50 thousand crore is based on imported capital goods. About Rs. 100 thousand crore of industrial turnover has had the experience of using imported know-how in the past or indigenised imported products through their own efforts.

Technology Policy Statement (TPS)

The technological change has been one of the major stimulating factors in the industrial growth of developed countries. During the last decade, there have been great strides all over the world in technology. The TPS of 1983 has amply recognised the enormous presence of imported technology in our country and has, therefore, laid down, as one of its objectives, the efficient absorption of imported technology appropriate to national priorities and resources. The policy statement stresses on the importance of productivity and absorption of modern technology. Para 5.4 of the TPS read asunder:

> "There shall be a commitment to ensure an adequate scale of investment in R&D for the **absorption, adaptation** and, wherever possible, **improvement** on and generation of new technology, making fullest use of overall national capabilities. Only thus can self-reliance be ensured and technology generation process established firmly."

The statement further stresses upon the provision of fiscal incentives for efforts directed to absorb and adapt imported technology, and that "there shall be a firm commitment for absorption and adaptation and subsequent development of imported know-how through investment in R&D to which importers of technology will be expected to contribute."

Trends in Collaborations and R&D

While there are nearly a thousand foreign collaborations every year and recent payments for technology have been about Rs. 600 crores per annum, bulk of technology imports take place in major sectors such as electrical and electronics industries, industrial machinery and machine tools, transport equipment, chemicals and petro-chemicals and metallurgical industries. The equipments and systems required for high investment/core sectors viz. railway products, power equipments, industrial machinery, earth-moving and construction equipment, process instrumentation for power and chemicals, machine tools involve continuous import of technology. Acquisition of technology is also prominent in other core sectors such as shipping and transport equipment, professional electronic equipment/systems and their ancillaries. There is a strong presence or dependence on major foreign companies around the world in areas such as electrical equipments, electronics, transport equipment, drugs and petro-chemicals. The payments for import of technology have increased from about Rs. 144 crore (for 588 collaborations) in 1982 to about Rs. 400 crore (for 903 collaborations) in 1987. In the meantime, R&D expenditure by industry has gone up from 270 crore to Rs. 600 crore. It can be seen that technology payments have doubled per collaboration, while the ratio of R&D expenditure to technology payments has reduced from 2:1 to 1.5:1. This reflects the increased rate of technology payments and reduced intensity in R&D. A study of R&D payments and technology payments in Japan and USA in comparison to India indicates that industrial R&D expenditure is very small in India. Further, the ratio of R&D spending to technology payments is also meagre compared to the other two countries. Dependence on foreign technology is the least in USA while Japanese have spent seven-fold in R&D though they depend on foreign technology. While these are broad indicators of technological dependence in India, it brings home the important need for increased investment in R&D, particularly for absorption and upgradation of imported technology. The efforts of Indian industry will therefore have to be streamlined in priority areas to plan and undertake need-oriented innovative absorption and upgradation projects. This will enable industry to quickly catch up with higher levels of technology, which otherwise may have to be imported again.

Activity 2

What is the effect of "Technology Import' on R&D activities in your company or airy other company that you are aware of?

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7.6 TECHNOLOGY ABSORPTION EFFORTS: INDIAN EXPERIENCE

An indepth assessment of absorption efforts of over 50 major industrial units in different sectors has brought out some of the constraints of Indian industry as follows:

— Lower scales of production compared to international levels, even in areas amenable to scale sensitive sectors/use of latest technologies.

— Lack of attention to absorption of technology in the absence of any compulsion to be internationally competitive.

— Continued access to collaborators on nominal payments, assured market and inadequate allocation of resources for R&D have resulted in insufficient attention for effective absorption and improvement of imported technology.

— Minimal involvement of R&D personnel in assessment of technology, further negotiations and transfer, and transfer, in implementation of technology.

— User's preference to imported technology based products and collaborator's guarantees.

Other reported constraints impeding technology absorption include delay in clearances, project overruns in turnkey jobs, difficulties in translation, inadequate training/expertise, incomplete documents, lower volumes than planned, lower initial investments to play safe, delay in import of equipments/components, delayed market response, and bottlenecks without adequate assistance by collaborator.

Suggested Measures

Indian industry has been expressing -its views on various matters connected with absorption through press, seminars and representations to the Government from time to time. Their views and suggestions may be summarised as follows:

- The units should have their own technology policy for its acquisition, absorption and adaptation, on long-term as well as short-term basis.
- Travel grants and incentives may be considered.for participation in international seminars/symposia etc. as well as for training abroad to keep abreast with the latest development in their fields.
- The R&D personnel from in-house/national laboratories etc. should be involved intimately in the transfer of technology from the conceptual stage itself.
- Incentives and support should be given for prototype development and testing facilities, pilot studies etc. for adaptation, absorption and upgradation of imported technologies. Also, support for using the services of experts/consultants on short-term basis may be considered in specific cases.
- There needs to be a closer interaction amongst in-house R&D units, national R&D laboratories, academic institutions, design organisations and consulting firms. Also, international R&D collaborations can be encouraged,
- Information about the acquisition of foreign technologies should be widely disseminated with a view to making R&D personnel aware of the needs of the industry. It enables them to formulate the programmes accordingly.
- Tax benefits and fiscal•incentives may be considered for investments made in absorption and upgradation of processes/products.
- In case of fast changing technologies such as electronics, foreign collaboration agreements should be of shorter durations.
- R&D expenditure should be generally 5 to 10% of the annual turnover of the company, particularly in areas of high rate of obsolescence.
- An information base for modern available technologies on global basis should be set up.
- The development of new products is very expensive and time consuming. It is generally not economical for the industry because of the low volume of manufacturing and fragmentation of capacity. Small/medium industries are not able to do any significant technology absorption exercises since most of them do not have their,own.R&D facilities in a meaningful way.
- Import of technology and know-how is limited to product design in most of the cases and manufacturing processes are directly related to the volumes of production abroad: They are uneconomic for the Indian firm and need be scaled down to meet the local demands. Consequently, quality andfinish may often suffer.
- Availability of indigenous materials (such as high temperature resistant alloys, engineering plastics, etc) is very poor.
- The standards for various products, components and materials need to be revised and updated on continuous basis particularly for industries like automobiles.
- A complete documentation of all the national research facilities may be compiled with regard to their activities and. developments carried out by theta. Such documents should be periodically updated and transmitted to the industry,

other national laboratories and R&D centres.

- A periodical review meeting of the R&D chiefs of the industrial units to discuss technology absorption efforts may be organised.
- Incentives should be given fo firms for adhering and following a faster phased manufacturing programme as specified in the collaboration agreement. A useful index could be "net foreign exchange savings". year to year over the duration of the project.
- A time-bound. programme for absorption and adaptation of imported technology should be drawn by the company immediately after the collaboration agreement.

7.7 MANAGEMENT OF TECHNOLOGY ABSORPTION

The Indian industry, on the whole, has achieved a good capability in implementing and adapting foreign technology as seen from the various experiences in different sectors. However, industry's technological capabilities across the major sectors, have in numerous instances, been found to be lacking in the areas of design/know-why analysis.

Areas needing attention

Indian industry needs to concentrate its efforts in filling up of the gaps in technology absorption and upgradation, particularly in the following areas:

- Accelerated indigenisation and improvement of raw materials/ components/ sub-systems through speedy R&D efforts with vendors/ ancillaries.
- Basic investigations and projects in research, design and engineering, encompassing process/product design analysis/optimisation/improvement, product designs for higher ranges/new applications, exports, process design and engineering for higher volumes and exports.
- Analysis and improvement of designs and development of tailor-made production equipments.
- Demonstration of improved/higher range of products/ equipments of the users.

All the above efforts would require well planned target-based, time-bound projects, strong technical groups, skills/ expertise and comprehensive R&D facilities.

Projects

Technology absorption projects could be organised or established on:

i) individual unit basis; or/and

ii) collaborative or cooperative basis, i.e. `club' projects involving users, manufacturers, national research laboratories or institutions. At present there is a need for stronger linkages in research and development work between manufacturers and users and between institutions/national. laboratories and industry.

Skills and Facilities for Technology Absorption

R&D skills and facilities in industries have been, by and large, good in so far as "indianisation" of foreign technology is concerned but they have been poor/unsatisfactory in case of basis design/know-why/improvement efforts. Some areas for resource development within industry are:

a) Use of qualified and experienced engineers/scientists. ,

b) Skill improvement by training/continuing education in institutions/research organisations iri the country or abroad.

c) Updating and augmenting of existing R&D facilities with 'state of the art' facilities to take up sophisticated investigations.

d) Use of cooperative, national or international R&D facilities for basic R&D

investigations in industry.

User Involvement in Absorption

Presently, user organisations such as large companies (e.g., in public or private sectors in various areas such as metallurgy, power, transportation, machinery, petrochemicals, etc.) are yet to have comprehensive interaction with their ancillaries or vendors with imported technologies in assessing or promoting technology absorption. This activity needs to be enhanced. Further it is necessary for Indian industry, in general, to rise from technological dependence and technological 'decaying' to a higher level of technological excellence. This calls for concerted steps by industry, other associated agencies, and Government, through promotional measures.

Some International Experiences

Many Latin American countries have created registers of licensing agreements, and have adopted legislative and administrative measures to regulate technology imports. In Korea, a law for Promotion of Technology Development was enacted in 1972 to encourage industry to develop new technologies on the basis of R&D activities undertaken by the Government subsidised laboratories. Tax/financial incentives were also provided. In 1977 the law was amended interalia to extend these incentives to a large number of industries, while R&D was made mandatory for strategic industries including electronics. A revolving fund was created to finance rapid absorption of foreign technologies, particularly those in a semi-developed state.

Under the Promotion of Technology Development Law, research funds were made exempt from taxes. This law relied heavily on tax incentives for research expenditure, research equipment and pilot products etc. These benefits and facilities could be used by importers of products and technologies for substitution, absorption or improvement of imported technology. The Korean law made it obligatory for [tic importers of technology and products to declare reserves of monetary resources for R&D. Upper limit for this research expenditure was :100⁹/ of the value of imported technology and 1% of imported equipments/product. It is strongly felt that it was the. R&D activities and technical improvements in Korea during the 60s and 70s that was responsible for bridging technological gaps.

In Peru, there is a practice of collecting funds from industry for R&D which is based as a certain percentage of income. Such funds are managed by an autonomous body ITINTEC (Institute of Industrial Technological Research and Standards) for supporting research and development activities. In Indonesia, imported technologies are expected to increase value added in the products manufactured while increasing the capability to understand new techniques, designs and production processes.

A recent Chinese experience reflects the need for arranging project investments to cover technology importation, absorption, adaptation and further development as a package plan. In Japan, industries have been guided by MITI for importing' technologies and for undertaking upgradation and innovation efforts to meet domestic demands and to aggressively undertake export as a deliberate policy step. Major national R&D projects involving R&D agencies and industries in new energy areas (Sunshine Projects since 1974) and Energy Conservation (Moonlight Projects since 1978) have been carried out. Success of these projects has promoted the Japanese Government to launch many national R&D projects in areas such as new materials, biotechnology, flexible manufacturing systems etc.

Activity 3

Discuss the "technology absorption management strategy" of a company (with 'which you have some familiarity) which has imported state of the art technology for a particular- product and now desires to remain competitive and grow faster in domestic and export markets.

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7.8 GOVERNMENT INITIATIVES

Government has, over the years, directed the industry to take necessary steps to set up R&D units for upgradation and absorption of imported technology. There is also a stipulation with respect to this in the terms and conditions of foreign collaborations. However, it has not been very effective. While formal extensions of collaborations have not been numerous in comparison to the number of new collaborations, Indian industry has quite often gone in for further collaborations to avail of technologies for higher ranges/capabilities or improved process/production techniques. The newer grass-root plants have used later technologies, but they are also likely to become obsolete as the years pass by unless necessary efforts to catch up with technical changes are made. Industry, in general, stays at a particular level for a number of years and then consider a jump in product range or volume of production through further technology induction. Pursuant to the Technology Policy Statement, the Government had stipulated that industries using technologies costing more than a payment of Rs. 2 crores should bring out comprehensive Technology Absorption, Adaptation and Improvement (THAI) plans. Government had also directed industry to submit annual returns for technology implementation and absorption.

You might have heard about the New Industrial Policy 1991 which has ushered in further liberalisation and consequent easy clearances and procedures in approval of foreign collaborations. Industrial licensing is not required except in some identified areas. This- is expected to bring about speedier acquisition and implementation of foreign collaborations.

Technology Ahsorption and Adaptation Scheme (TAAS)

The Technology Absorption and Adaptation Scheme (TAAS) was initiated by the Government (DSIR) as a pilot scheme during the 7th plan. TAAS aims at stimulating and accelerating the efforts of Indian industry in technology absorption and upgradation. About 30 public and state sector units have so far been partially supported for undertaking identified RDDE (Research, Design, Development and Engineering) projects to absorb and upgrade specific elements in imported iechnology. The support is for accelerated indigenisation/import Substitution/ know-why exercises/ product improvement and optimisation. An amount of over Rs. 20 crores has been marshalled through a partial support in various major sectors such as electricals/electronics, metallurgy, industrial machinery and chemicals. The projects are overviewed by Evaluation Committees. Under the scheme, other initiatives such as workshops, technology absorption /profile studies of different states and technology evaluation studies. of critical sectors have been undertaken. All these have encouraged the participation of industry, national institutions/ laboratories and Government in dealing with issues of technology absorption. The details of the scheme and activities undertaken under the scheme as reported in DSIR Annual Report 1990-91 are given in Appendix 1. In order to further illustrate the project details and benefits of TA exercises, two examples (M/s NGEF and M/s Balmer Lawrie & Co Ltd.) are also given in Appendix 2

The noticeable benefits from this scheme include foreign exchange savings, setting up of recognised R&D groups involving about 150 persons, involvement of over 20 national institutions/ laboratories in collaborative projects with industry, and R&D commitments at top management levels in industry. Know-why actions and attempts for bridging technology gaps (not normally attended to by industrial units) are now being undertaken e.g., software development by Praga Tools for Ceritral Machine Tools Institute; accelerated indigenisation by Instrumentation Limited, Kota; fork lifts in hydraulic systems by Punjab Tractors; debottlenecking efforts and R&D assistance for making gamma BHC by Indian Institute of Chemical Technology for Southern Pesticides Corporation; Extra High Voltage transformer know-why studies by NGEF Co., Bangalore, etc:

TAAS activities have resulted in stimulating and speeding up the R&D work in' absorption of technology. The scheme, therefore, is in a good position to encompass larger areas, to demonstrate the beneficial effects of organised and target-oriented absorption of technology projects. TAAS has brought out the need for enhancing the activities to catalyse and assist the industry in technology absorption.

TAAS is expected to extend partial support to the following:

- Core sector users in absorption and upgradation of products/equipments from ancillaries/equipment manufacturers/vendors whose technologies are based on foreign collaborations.
- 'Club' or cooperative projects of interest to the sector, involving a group of manufacturers, users, and national institutions, in identified areas of technology gaps.
- Industry-sponsored projects with national laboratories/institutions.
- Projects of small and medium enterprises, in priority areas such as energy saving, accelerated indigenisation, efficiency and technology upgradation.
- Skill utilisation in technology absorption projects by hiring of research experts and NRI specialists as well as training in national laboratories/ institutions/ international organisations for identified areas of absorption.

Technology Evaluation Studies

In order to assess the performance of technology in the major sectors of Indian industry, and to assess the gaps in technology and to suggest possible programmes for R&D and technology upgradation, the Government has initiated studies in various important areas such as fertilizers, steel, cement, ministeel, forgings, foundry, aluminium, etc. Over 50 sectors have been identified and in about 30 sectors, studies have been commissioned. The reports whenever they come are widely discussed in industry, Government departments and other concerned organisations, and disseminated. The reports bring out the need for accelerated effort in technology generation and absorption. `Technology demonstration' is also envisaged in some important identified areas in order to speedily introduce new technologies.

National Register of foreign collaborations in DSIR has also commissioned technology status studies for over 100 items for which repetitive import of technology has taken place. These studies bring out technology gaps and needed thrusts for technology 'absorption.

Other Initiatives

To promote technology generation and upgradation, financial institutions like IDBI, ICICI, IFCI have introduced loan schemes to support R&D projects by Industrial entrepreneurs.

7.9 BENEFITS OF TECHNOLOGY ABSORPTION

The benefits accruing from technology absorption exercises, as evidenced by Government and industry experiences so far, are as follows:

- Repeated collaborations for the same product/process are avoided.
- Acquisition of further technologies becomes selective.
- Ability is developed to unpackage technology.
- Savings can be effected in foreign exchange due to indigenisation/use of indigenous alternatives.
- Effective utilisation is made of available indigenous research expertise and facilities to achieve the desired results.
- Know-why and technology upgradation capabilities are built-up.
- Exports are, increased.
- Technically competent groups of scientists and engineers trained in technology absorption get matured and strengthened.
- The base for technological self-reliance is enhanced.

Benefits arising from Technology Absorption exercises are summarised in Figure 7.4. The benefits could range from a **greater commitment** of management for increased R&D to larger sales and profits, sustaining the growth of the company through technological strength.

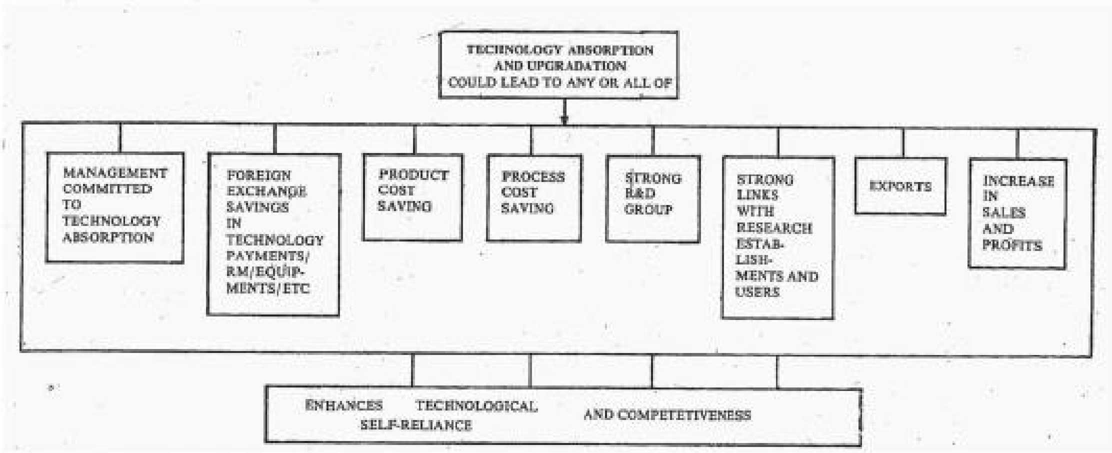

Figure 7.4: Benefits of Technology' Absorption and Upgradation

7.10 FUTURE THRUST FOR TECNOLOGY ABSORPTION

Many developing countries including India have liberalised their industrial policies in the recent past.

In themake of the liberalised nature of New Industrial Policy and other policy measures in Trade and Finance, it has become imperative for industry to accelerate its R&D efforts to meet the emerging competitive environment.

While acquisition of technology is now easier, commensurate R&D efforts will simultaneously be needed to absorb and upgrade the acquired technology in order to become internationally competitive. The thrust as underlined below will need to be ensured for implementation, absorption and upgradation of imported technology.

- Industry should attempt to obtain best available technology closest to international trends and provide R&D at the stage of project planning. • Speedy indigenisation of raw materials and components.

- Efforts for unpackaging and indigenisation of tailor-made equipments in the acquired technology.
- Enhancing exports of products based on absorbed and upgraded technology. • Contiruous training of research personnel in India and abroad.
- Use of national and international research facilities and expertise.
- Involving users, suppliers of components and materials, research organisations in undertaking absorption exercises.
- Acquiring latest information on technologies and industrial R&D around the world.
- Involvement of senior R&D personnel in negotiations and acquisition of technology.
- User's support for development and speedy, utilisation of absorbed and upgraded product.
- Setting up of research advisory committees by major companies, importing high cost and complex technologies.
- Support by Government to catalyse the above efforts of industry to ensure effective and complete absorption and upgradation of imported technology.

7.11 SUMMARY

Foreign technology has played a key role in Indian industrial development. Our major industrial sectors have availed of imported technology to keep pace with international technological changes. Government has stressed the need for absorption of imported technology as well as technology development. However, industry's R&D spending has not been commensurate with payments (royalty, etc.) for technology. Industry's absorption efforts need to be accelerated to bridge the technology gaps.

Technological dependence has been in software, hardware and in services. All this needs to be minimised. Industry has the capability to adapt foreign technology, but gaps exist in absorption effort in unpackaging technology, know-why exercises, optimisation and upgradation. Many constraints exist in effectively absorbing technology such as low volumes of production, lack of R&D commitment etc. Important aspects in managing technology.absorption include organised in-house R&D efforts in priority projects, involvement of users, collaborative and sponsored projects, etc. Need also exists for upgrading R&D skills and facilities. Government has taken various steps to hasten absorption. The Technology Absorption and Adaptation Scheme (TAAS) aims at catalysing the technology absorption efforts, to reduce dependence and to strengthen R&D capabilities. Many projects supported so far have brought out savings in import substitution, enhanced know-why expertise, and stronger R&D groups.

Project linkages with national laboratories add institutions have been effective. Benefits of technology absorption include selectivity in further acquisition of imported technology, ability to unpackage, foreign exchange and cost savings and stronger technological capability and research linkages. The future thrust of industry should therefore be on quick implementation of planning and need-based, time-bound, organised technology absorption programmes while acquiring foreign know-how. In these efforts, concerned research organisations and institutes could also be well'utilised. Industry with a view to becoming internationally competitive should undertake exports based on their R&D and absorption, efforts. Industry need also to continuously interact with all development agencies and the Government for accelerating their efforts in technology absorption.

7.12 KEY WORDS

Absorption: A full understanding of the technology acquired which would essentially mean unpackaging it. This would imply that the buyer of technology has developed the capacity to further optimise, upgrade or improve the technology through R&D efforts.

Adaptation: Alterations or modifications made by the buyer (or user) in the technology acquired so that it suits the local conditions and becomes more appropriate/relevant to the operating environment.

Adoption: Suitable modifications or alterations in the features/ characteristics of the technology by the supplier to suit the requirements of the buyer. This is a pre-transfer, action undertaken by the seller and forms part of the technology package.

Capital Equipment: Production equipments and other related goods used in manufacture of a product.

Core sectors: Important industrial sectors of economy such as coal, power, telecommunications, petroleum, fertilisers.

Improvement and upgradation: All the efforts aimed at improving the quality or usefulness of the product constitutes improvement or upgradation of technology.

Know-why: The basic knowledge behind the know-how. Examples are such as design analysis and calculations in a product or process development, metallurgical and engineering design evaluation information, the `why' aspects of the documents and services in transfer of technology, the knowledge on performance/design parameters, and. effects of their variations in product/process technology.

Know-Show: Consists of software documents and allied knowledge based services to assist an enterprise to undertake manufacture.

Optimization: All the efforts undertaken by the user of technology to effect savings through R&D or value engineering in the use of material, energy etc. in the product or processes.

7.13 SELF-ASSESSMENT QUESTIONS

1) Elaborate on what constitutes a foreign technology package and technological dependence.
2) Describe the dependence of Indian industry on. imported technology. what has been the performance of Indian industry in R&D?
3) Explain the different concepts in relation to acquisition of imported technology, viz., adoption, adaptation, absorption, optimisation, improvement and upgradation.
4) Distinguish between 'Technology Adoption' and 'Technology Absorption'. Technology Absorption leads to 'know-why' of a technology package and understanding of 'know-why' leads to the better competitiveness for a company. Comment.
5) What constraints or problems in imported technology are being experienced by Indian industry and what are the major ¨suggestions from industry to

minimise such constraints?

6) Explain the management of technology absorption, particularly in relation to projects, skills, and facilities user's involvement.

7) "Indian companies generally do not invest in Technology Absorption and are solely dependent on periodic import of know-how for the same or similar product. Comment.

8) Indian companies do not distinguish between `Technology Absorption' and `Technology Adoption". Comment.

9) What initiatives has the Government taken in promoting technology absorption?

10) Describe the major benefits which could accrue from effective absorption of imported technology.

11) Explain what should be the main elements of the future thrust of Indian industry for accelerating absorption of imported technology.

7.14 FURTHER READINGS

AIST, 1980. *Building an Advanced Technology Intensive Economy for Japan,* MITI, Japan.

Fransman, Martin and Kenneth King, 1984. *Technological Capability in the Third World,* Macmillan.

Twiss, Brian and Mark Goodridye, 1989, *Managing,Tgchnology for Competitive Advantage,* Pitman.

Appendix 1
Technology Absorption and Adaptation Scheme (TAAS)

Activities in 1990-91

1. Introduction

The Technology Absorption &Adaptation Scheme (TAAS) in the Ministry of Science & Technology has been introduced to enable absorption and upgradation of imported technology. An inter-Departmental Advisory Committee has been set up in DSIR to advise and review the activities and junetioning of the Scheme besides approving new projects to be undertaken.

2. Objectives and Functions

2.1 The major objectives of the scheme are:

- To reduce the necessity for further import of technology after having it in use over a long period.
- To upgrade the technology imported, incorporating improvements identified during its use.
- To strengthen the base for selecting and negotiating appropriate and competitive technology.

2.2 The main functions for achieving the above objectives are:

- Catalytic support to the industry for technology absorption exercises and upgradation programmes related to imported technologies.
- Monitoring and evaluating the efforts in implementation of technology and absorption exercise by the industry.
- Technology evaluation & norms studies in important sectors/areas.
- Information dissemination through Seminars/workshops/ training related to imported technology.

3. Activities

3.1 Support/Assistance for Technology Absorption/Upgradation Projects and Strengthening R&D base.

3.1.1 The scheme provides promotional support and assistance to the industry for technology absorption and upgradation exercises related to imported technologies. Financial support is essentially catalytic in nature and is directed to trigger and stimulate target oriented technology absorption activities by the industry.

3.1.2 Proposals include projects for filling up of technology gaps in aspects such as:

- Product/process technology evaluation exercises/analysis.
- Process/product/production technology optimisation and upgradation.
- Evaluation and upgradation of existing process/equipment through design investigations and development work.
- Accelerated indigenisation/substitution of imported raw materials/components.

3.1.3 Projects of 24 companies involving over 45 projects have been approved so far for absorption exercises related to imported technology. The support has been for the developmental expenditures such as prototype/pilot plants build up/raw materials/components/testing/consultancy, user trials etc. while capital and other expenditure are expected to be borne by the industrial units themselves.

Project periods are usually 2 to 3 years. The names of the companies whose projects have been approved are:

i) M/.s Instrumentation Limited, Kota
ii) M/s Punjab' Tractors Limited, Chandigarh
iii) NOFF T,imited- Rnnvalore
iv) M/s Praga Tools Limited, Secunderabad
v) Kerala Minerals & Metals Limited, Quilon
vi) M/s IBP Co. (Chemical Division), Ltd., Gurgaon
vii) M/s Balmer Lawrie & Co. Ltd., Calcutta
viii) Southern Pesticides Corporation Ltd., Hyderabad
ix) IBP Company Limited (Engg. Division), Nasik
x) M/s Hindustan Antibiotics Limited, Pune
xi) M/s Hindustan Latex Ltd., Trivandrum
xii) M/s Bharat Earth Movers Limited, Bangalore
xiii) M/s Gujarat Communications and Electronics Ltd., Baroda
xiv) M/s Kerala State Electronics Development Corpn. Ltd., Trivandrum
xv) M/s Mishra Dhatu Nigam Limited, Hyderabad
xvi) Electronic Corporation of India Ltd., Hyderabad
xvii) M/s Hindustan Machine Tools Limited, Bangalore
xviii) M/s Uptron India Limited, Lucknow
xix) M/s Andrew Yule & Company Ltd., Calcutta
xx) M/s Hindustan Machine Tools Ltd., Pinjore
xxi) M/s Tamil Nadu Industrial Explosives Ltd., Vellore
xxii) Tamil Nadu News Print and Papers Ltd., Madras
xxiii) Hindustan Teleprinters Ltd., Madras
xxiv) M/s Metallurgical and Engineering Consultants (I) Ltd., Ranchi

3.2 Technology Profile Studies: The Profile Studies of imported technology in 19 States have been initiated. The reports will contain details of existing industrial units, based on foreign collaborations: brief highlights of absorption of technology and a broad analysis of collaborations in the concerned states. The draft reports covering 9 states viz. Delhi. Himachal Pradesh, Haryana, Punjab, Kerala, Maharashtra, West Bengal, Orissa and Rajasthan have been finalised, and those of 8 more states are being finalised.

3.3 Implementation of Foreign Collaborations: The studies on implementation of foreign collaborations approved on 1981-1983, 1984 and 1985 undertaken by Consultancy Development Centre have been completed. The reports are being finalised. These studies aim to evaluate the present status with regard to implementation of foreign technology approvals. The reports throw light on aspects such as reasons for non-implementation of approved cases and constraints in implementation.

3.4 Video Film on Technology Absorption: The preparation of video film on technology absorption has been undertaken. The film would cover the highlights of technology absorption projects supported under TAAS.

3.5 Technology Evaluation and Norms Studies: 3.5.1 Under the Scheme, Technology Evaluation and Norms Studies were initiated in various sectors/areas of importance. The norms studies inter alia aim at identifying major elements of technological gaps and to formulate the time targeted project/programmes for technology acquisition/R&D/modernisation/operational improvements to bridge the technology gradients existing between India,nnd international levels of operations. These aims are pursued through supporttneaf sectoral and unitwise studies. The technology norms studies in 40 sectors/areas have been commissioned so far through professional consultants in their' respective fields. 50 more areas for the studies have been identified in consultation with other Ministries/ Departments.

3.5.2 The reports on electric lamp, non-ferrous castings, ministeel, fertilizer (phosphatic), fertilizer (nitrogenous). aluminium, boilers, forged and portable tools, paper and pulp machinery have been finalised and printed. The reports on steel forgings, drug formulations, steel and ferrous foundry have been finalised taking into account the observations in the respective workshops recently held and are being printed. The draft reports on pumps, fire-fighting equipment/systems, ceramics, plastic processing and caustic soda industry have been finalised while the draft reports on industrial furnaces, ferro alloys, refractories, flour and rice mill and cement are ticing finalised. The studies which are under progress include Pesticides, Electrical Motors, Packaging, H.T. Fastners, Rubber Processing Sulphuric Acid,
Edible Oils, Medical Elecfrohic Equipments, Industrial Oils, Leather Tanneries, Leather Products and Secondary Aluminium Products. Other studies commissioned during the year are in,the areas of Home appliances. Marine food products, Industrial Alcohol and Fruit juices industry.

3.6 Workshops: Four workshops concerning Technology and norms in Steel Forgings, drug formulations, steel-and ferrous foundry industries were organised. Four more workshops including those on Pumps, Fire-fighting equipment system, ceramics industry are being planned in early 1991.

3.7 Talented Indian Engineers and Scientists (TIES:) Talented Indian Engineers and Scientists Scheme (TIES) is one of the measures redommended by a Committee constituted by the Minister of State for Science & Technology to review the policy of Government and various schemes already in operation for attracting back talented Indian Scientists and Technologists settled/working abroad. These recommendations were further endorsed by Scientific Advisory Council to Prime Minister.]

The "Talented Indian Engineers and Ccientists Scheme (TIES)" of the Department of Scientific &'Industrial Research aims to streamline and co-ordinate all activities in providing assistance to Talented Indian engineers and Scientists, in areas such as: ascertaining the TIES expertise and intentions: awareness of areas of importance: status. and feasibility reports; clearances like industrial licenses; foreign collaborations and capital goods, finances, RBI approvals etc.
In pursuance of these objectives, DSIR is initiating activities such as preparation of pre-investment feasibility projects on selected items considered to be of interest to TIES.

(Adapted from: DSIR Annual Report, 1990-91)

Appendix 2
Examples of Technology Absorption

NGEF Limited, Bangalore

1. Background of the Firm

The firm was established in 1964 and is engaged in the production of electrical egpipnients such as transformers, Induction motors, alternators, switchgears etc. The firm's annual turnover in 1987-88 was Rs. 117 crores. The firm have entered into several collaborations such as M/s TU Nurnberg, West Germany for EHV transformers;. M/s Alsthom, France for instrument transformers, M/s. AEG Telefunken'AG, West Germany for 3 phase Induction motors etc.

The In-house R&D unit of the firm is recognised by DSiR. The R&D expenditure during last three years was around Rs. 82 lakhs. R&D achievements include Vacuum Circuit Breakers for Voltages up to 11 KV, High fr equency transistorised Static inverters, submersible motors and pumps, insulation systems for dry type transformers, self-protected transformers for rural electrification etc.

2. Details of the Project

2.1 The Project: The project concerns technology absorption exercises related to technology involved in 400 KV EHV transformer Insulation system and the exiensi6n of the'same for data collection in 765 KV UHV transformer insulation system.

2.2 Imported Technology related to the Project: The know-how for the manufacture of 220 KV & 400 KV range of EHV transformers has been received from)M/s Transformatoren Union Aktiengesellschaft (TU), West Germany. The Scope of technical information received from the Collaborators cover peripheral design data, arrangement of insulation systems, regulations to prepare production drawings and manufacturing processes.

2.3 Major Objectives:

a) Improvements in reliability of EHV transformers.
b) Optimisation of insulation system in 400 KV transformer,
c) Employment of modern instrumentation, process and diagnostics for reliable- `& upgraded manufacture.
d) Technology upgradation of higher range of insulation systems.,
e) Indigeinisation/import :Substitution.

2.4 Action Plan

- Literature survey.
- Model construction & evaluation .
- Study partial discharge behaviours by employing advanced techniques..
- Procurement/ Development of softwares for design analysis, optimisation, electrostatic field evaluation etc.
- Field stress evaluation of EHV transformers.
- Consultancy from foreign experts and national labs/ institutions.
- Establishment of equipments/lab facilities.

2.5 Financial Outlays: The total financial outlay of the project is about Rs. 50 lakhs ' -including Rs. 31 lakhs in Capital Equipments. The DSIR support is Rs. 15 lakhs towards the development expenditure such as for consumables, software development,.visit of experts and research consultancy from National labs/institutions.

2.6 Duration of the Project: 3 years

2.7 Anticipated Results:

- Self-reliance in EHV insulation system technology.
- Strengthening design base for improving reliability of the product, cost reduction and upgradation of the insulation system.
- Development of advanced softwares for stress evaluation, design improvement and optimisation.
- Indigenisation resulting in foreign exchange savings.
- Reduced dependence on collaborators for higher range of transformers.

3. Technical Evaluation Committee

A Technical Evaluation Committee, (TEC) including members from Ministry of Industry, DGTD, NRDC, ERDA, IISc, CPRI, CEA, was constituted to monitor and evaluate the progress of the project. The highlights of suggestion/directions rendered by TEC to the firm included the following:

- The firm should establish a separate R&D group to undertake the project.
- The firm should set up equipments/lab facilities for model studies & evaluation of 400/765 KV transformers.
- The firm should involve IISc, CPRI and NAL for Consultancy and advanced testing-IISc for Software advice and CPRI, and NAL for testing & evaluating properties of insulation materials.
- The firm should attempt to work on optimised models for obtaining economical design of EHV transformers, and to extend the evaluation work to insulation systems of 765 KV transformers.

4. Progress of the Project

- High voltage laboratory eqipped with test apparatus, instrumentation & data acquisition system for study of partial discharge (pd) behaviours in critical zones, has been established.
- A sophisticated In situ process-cum-testing prototype has seen developed & manufactured for experimental studies on 400/765 KV insulation system. The In situ testing concept helps generation of data for upgraded insulation system.
- Softwares have been acquired/developed to have advanced design analysis on full scale transformers and models. The firm have utilised the expertise of Prof. J.H. Mason, a research consultant from Brazil for Scrutiny of models & modelling concepts; Prof. O.W. Anderson, Norway for Software development, ES&EM fields, eddy current loss estimation etc.; Prof. R.E. James, Australia for identification of technology gaps between 400 & 765 KV transformer's design, materials &processing; Mr. V. Dahinden of M/s Weidmann, Switzerland for development of EHV/UHV transformer insulation system including selection of insulation material & process technology and IISc Bangalore for PD modelling, selection of software etc. National, labs/institutions consulted are CPRI for advanced P.D. measurement of models, NAL for particle analysis on press board, oil & paper and ISRO for computer & peripheral selection.
- 44 experimental models of 220 KV/400 KV and 24 experimental models of 765 KV transformers have been fabricated for experimental purposes, and a series of investigations have been undertaken.
- Dielectric and physical parameters of the system such as transformer oil characteristics, physical & dielecric properties of press board paper, moisture content in oil etc. have been measured and monitored.
- The shield tube for EHV transformers has been indigenised.

5. **Achievements/Expected Outcome**

- Self-reliance in EHV transformer insulation system technology.
- Economical designs and cost savings as a result of detailed field analysis and optimization.
- Improvement in design cycle time by using modern field stress computing system.
- Foreign exchange savings of about Rs. 7.2 lakhs & cost saving of about Rs. 4.50 lakhs, due to indigenisation of shield tube used in EHV transformers.
- Establishment of active interaction with national labs such as CPRI, IISc, NAL for building up capabilities in software development, advanced testing/measurements on full size EHV transformers and models.
- Exposure to foreign research and development specialists in areas such as design, software application, investigations. Test methods & process improvements.
- Ability to adapt advanced methods of stress evaluation in EHV Transformers, modelling concepts and partial discharge and failure prediction capability.
- Ability to evaluate the basis of designs and specifications of collaborators.

Balmer Lawrie & Co. Ltd., Calcutta

1. **Background of the Firm**

The firm was established in 1967 and is engaged in the production of greases and lubricants, steel barrels, freight containers, leather chemicals, LPG cylinders and speciality chemicals. The firm's annual turnover in 1987-88 was Rs. 163 crores. The firms have entered into technical collaboration with M/s Optimal Oelwerke, West Germany for manufacture of high performance third generation greases & lubricants.

The in-house R&D unit of the firm is recognised by DSIR. The R&D expenditures during last 2 years were of the order of Rs. 120 lakhs. The R&D achievements include development of steel rolling oils for steel plant, thread lubricants for oil exploration, synthetic non-carcinogenic grinding oil for precision parts, refining of used lubricant oils, sophisticated grades of greases for applications in steel, railways and defence sectors including low temperature greases, high pressure lubricants and Aluminium complex greases etc.

2. **Details of the Project**

2.1 The Project: The project concerns development and indigenisation of high performance greases, lubricants & their components; including study of know-why aspects of lubricant chemistry and performance.

2.2 Imported technology related to the Project: The firm has been producing high performance greases under technical collaboration of M/s Optimol Oelwerke, West Germany. The agreement provides process know-how for selected greases based on additives to be imported from collaborators.

2. 3 Major Objectives:

a) Development of indigenous additive components and packages,

b) Development of new grades of lubricants/greases, as an outcome of absorption efforts

c) Development of equipments for processing/ evaluation of high performance greases

d) Study of know-why aspects of characteristics/properties of high performance greases.

2. 4 Action Plan:

- Setting up of lab and pilot plant facilities
- Lab development of products
- Performance Evaluation
- Field trials
- Research consultancy/testing from naiional labs/institutions such as IIP, Dehradun.
- Availing services of renowned grease experts.

2.5 Financial Outlays: The total financial outlay of the project is Rs. 150 lakhs including Rs. 84 lakhs in capital equipments/pilot plant facilities. The DSIR support is Rs. 20 lakhs towards the development expenditure such as for consumables, research.consultancy, pilot plant, testing fees, certification etc.

2.6 Duration of the Project: 3 years

2.7 Anticipated Results:

- Development of indigenous capability for a wide range of high performance lubricants.
- Improvement in product quality, better productivity and conservation of resources.
- Improvement in processing techniques and equipments, raw material &' component selection resulting cost optimisation and better value engineering.
- Understanding of know-why aspects of lubricant chemistry and performance for building up present and future capabilities.
- Import substitution.

3. Technical Evaluation Committee

A Technical Evaluation Committee (TEC)*including members from. Ministry of Industry, Deptt. of Petroleum, DGTD, RRL Jorhat, NCL, NRDC, IIP, Dehradun etc., was constituted to monitor & evaluate the progress of the project. The highlights of suggestions/directions rendered by TEC to the firm included the following:

- The firm should establish a separate R&D group to undertake the project.
- The firm should possibly include investigations in the area of Tribology.
- The firm should explore channels for export of products/components developed e.g. tailor-made fats and synthetic base oils etc.
- The firm should take up joint projects with end users e.g, development of rolling oils in association with steel plants etc.

4. Progress of the Project

i) **Development of indigenous Additive Components & Packages**

- Development work related to lithium complex greases has been taken up.
- A new package for regular & EP grades of Aluminium Complex greases has been developed.
- Asa substitute for Mowah fats traditionally used, new tailor-made fats derived entirely from indigenous sources have been developed at pilot plant stage. Commercialisation is under implementation.
- Additive package for synthetic oils is under progress.

ii) **Development of new grades of lubricants/greases**

- • Pilot scale trials are in progress on indigenously developed Alunnimum Complex greases.

- Synthetic oil for Air jet looms has been indigenised.
- High performance compounds used in oil exploration rigs, have been developed.
- High performance tailor-made oils for Cold rolling of Steel have been developed in association with Bokaro steel plant.
- Work on synthetic high temperature chain oil, Heavy duty brake fluids etc.. is in progress.

iii) Equipment development:

- A scraper type heat exchanger for grease cooling has been designed and fabricated.
- Test Rigs for functional life test of greases is under fabrication.
- Test facilities have been planned and produced as per Schedules given in the project.

iv) Study of know-why aspects:

- Detailed study oncharacteristics of Aluminium Complex greases has been completed.
- joint study on performance of cold rolling oils has been carried out in association with Bokaro Steel Plant.

5. Achievements/Expected Outcome

- Development of Additive Components & finished products such as Aluminum complex & Non-Soap greases, tailor-made fat components for soda & calcium greases and high performance thread compounds is estimated to result in foreign exchange savings of about Rs. 4 crores/annum.
- 10-20% improvement in productivity of high performance greases due-to technology upgradation and equipment design.
- Annual savings of about Rs. 301akhs on account of indigenisation of additive components.
- Upgradation in technological skills and infrastructure of the firm.
- Technological independence in the area of sophisticated greases and lubricants.
- Development of newer products for key sectors like steel plants, Defence, Railways and Textile Industry.

UNIT 8 ASSESSMENT AND EVALUATION

Objectives

After studying this unit you will be able to:

- know the meaning and relevance of Technology Assessment (TA)
- apply the methodology of TA
- know the meaning and identify the factors involved in Technology Evaluation (TE)
- understand the need and importance of TE at the enterprise level
- appreciate the role of DSIR, Ministry of Science and Technology in India in Technology Evaluation in various sectors of industry.

Structure

8.1 INTRODUCTION

Technology Assessment (TA) and Technology Evaluation (TE) are very closely related terminologies and sometimes even overlap. Technology Forecasting (TF) is also generally dealt with in relation to TA and TE. You will recall that you studied about TF in Unit 4. We shall now study about TA and TE in this unit.

TA deals with assessment of a technology on a wider canvass than the immediate concerns of a firm. It covers in its ambit the direct and indirect effects and 'consequences of introduction and use of technology on diverse parties and in specific environments. TE seeks to evaluate, in relation to a firm or an organisation,, technical or economic or environmental benefits/parameters as affecting that entity. Thus, TA can be considered more of a macro level exercise while TE is more in the nature of a micro level exercise. National agencies and sometimes large corporations undertake TA exercises prior to introduction of technology while industrial enterprises, particularly in developed countries, undertake some sort of TE exercises in varying depths, prior to the development, acquisition or adoption of a technology. TA and TE are hence effective tools for evolving an efficient technology management system at the national and enterprise level respectively. The managers, need to develop sufficient familiarity with these tools.

8.2 TECHNOLOGY ASSESSMENT

Historically, every society in some way assesses the introduction of new technology in an implicit way, e.g. Tipu Sultan while-introducing rocketry in warfare made an, implicit assessment of the havoc the novelty of it would cause amongst the British soldiers, rather than its actual damage, distinctive effect. However, the distinguishing feature of present day technology assessment (TA) is that it is an explicit attempt to assess and consciously select the implementation of a new or expansion of an existing technology.

The birth of TA in its formal sense originated in early sixties when the Congress of USA, concerned with the pervasive and often undesirable effects of introduction of new technologies, especially on the environment, called for a new form of policy research and analysis to deal with the subject. TA thus has been largely applied in USA, and to some extent in France, Germany and other E.E.C. countries but very little in developing countries, including India. This is not to give the impression that since most new technologies originate in the developed countries, TA is undertaken in such countries and is of relevance to them. TA is also relevant to the developing countries. Consider, for example, the introduction of comp terisation in banking and insurance, farm mechanisation, robotics in assembly line manufacturing etc. Obviously their impact would be vastly different in the Indian context than say in USA or Japan. This would indicate that TA needs to consider the social, cultural, political, economic, and industrial environment not only of the country but even of different target groups within it.

Government departments, depending upon their responsibilities, have to form opinions about technologies say construction of a major dam, extending telecom facilities to rural areas, location of a `shooting range' for defence purposes, introduction of a new contraceptive, etc. In these tasks, technology may play from a major to a subsidiary role. Traditionally, for TA the government has relied on advice of civil servants, advisory committees, experts, commissioned consultancy reports etc. But these advisory arrangements are generally a far cry from the full-fledged formal TA that should be undertaken to help the government arrive at meaningful decisions for public good/interest.

8.3 DEFINITION

There are several definitions of Technology Assessment and all of them focus on the advantages of TA and are more or less similar in content. Emilo Daddario, the US Congressman, who is credited with coining the term TA in 1967, defined it as:

> Technology Assessment is a form of policy research which provides a balanced appraisal to the policymaker. Ideally, it is a system to ask the right questions and obtain correct and timely answers. It identifies policy issues, assesses the impact of alternative courses of action and presents findings. It is a method of analysis that systematically appraises the nature, significance, status, and merit of technological progress.

The definition used by the US Congressional Research Service, although slightly lengthy is more expressive and explicit, it reads as:

> Technology Assessment is the process of taking a purposeful look at the consequences of technological change. It includes the primary cost/benefit balance of short-term localised market place economics, but particularly goes beyond these to identify affected parties and unanticipated impacts in as broad and long range fashion as is possible. It is neutral and objective, seeking to enrich the information for management decisions. Both `good' and `bad' side effects are investigated since a missed opportunity for benefit may be detrimental to society just as is an unexpected hazard.

(Source: (for above two quotations) Wad A., and Radnor M., ***Technology Assessment: Review and*** *Implications for Developing Countries,*. UNESCO-Science Policy Studies and Documents No. 61, 1984).

It is thus obvious that TA attempts to derive a cause and effect relationship between the policy options to be pursued and their effects, both beneficial and harmful. It not only considers those effects that are apparently direct, but also those that are unforeseen, delayed or even indirect. The definition thus implies that if such and such technology is adopted, such and such is likely to happen and such and such groups in certain ways are likely to be affected leading to certain possible outcomes. It is then for the decision-maker to decide which effects are acceptable/permissible and which are not, and hence which policies need to be pursued or not pursued.

TA can be either problem oriented or technology oriented. Examples of problem oriented TA in the Indian context are: reducing imports of crude, optimisation of energy use, abolition of illiteracy, etc. The examples of technology oriented TA are: introducing bio-pesticides in agriculture, computerisation of railway operations etc. The problem related TA must obviously list all the available solutions of the problem and analyse their impact. The technology oriented TA must not only analyse the impact of a given technology but also study the rival/alternate technologies and their impact as well. Thus, basically both the types of TA deal with/involve the same procedures/methodology.

8.4 METHODOLOGY OF TECHNOLOGY ASSESSMENT

Due to the vastness and the inherent interdisciplinary nature of the subject and the complexities of the issues involved, there has often been ambiguity in defining what TA methodology should include. Here, the TA methodology is defined to include not only the listing and application of major stages in the TA process itself, but also the organisation and the management of TA exercise.

Stages in the TA process

Several well-known authors' on the subject have listed what are considered as the key stages in the TA process. Some of these are given in Table 8.1.

Table 8.1: Stages in Technology Assessment

		Defined By Centre		
Stages	Porter et al (1980)	Jones (1971)	J. Coates (1976)	Armstrong and Harman (1977)
1.	Define Problem	Define assessment task	Examine problem statements, Identify parties interested	Define the assessment domain
2.	Describe Technology	Describe relevant technologies logics	Specific systems alternatives, Identify macro-system alternatives	State data acquisition parameters
3.	Technology forecast			Technology projection
4.	Social description & social forecast	Develop state-of society assumptions	Identify exogenous variables or events	Whole societal futures Societal values.
5.	Identify Impact	Identify impact areas	Identify possible impacts	Select impact criteria
6.	Impact analysis	Make preliminary impact analysis	Evaluate impacts	Predict and assess impacts
7.	Evaluate Impacts			Impact comparisons and presentations
8.	Analyse Policy Options	Identify possible action options, Complete impact analysis	Identify decision apparatus, Identify action options for decision apparatus	Analyse policy options
9.	Communicate results		Conclusions (and possibly recommendations)	Validation, public participation

Source: Porter, Rossini, Carpenter and Roper, 1980, *A Guide Book for Technology Assessment and Impact Analysis*, North-Holland (Publishers), New York.

A brief explanation of the various stages is given below.

Problem Definition: This involves the proper specification of the problem to be studied and establishing its limiting (bounding) parameters. Automatically the questions that need to be answered are:

a) For whom or what purpose is the study being done?
b) Who are the affected groups/targets?
c) Over what time horizon is the problem to be studied?
d) What is the spatial/geographical coverage?
e) The extent/range of technological options to be covered?
f) What is the choice of projected societal values and structure?

It should be recognised that this stage is not a one time exercise, but a continuous process that permits the problem to be refined and redefined as the study progresses.

Technology description/forecast: The three main elements of technology description are (a) establishing the boundary of the technology per se (b) the data pertaining to the technology to be acquired and (c) technology forecast. Thus, this basically involves defining the current state of the art of the technology and projecting it into the future along feasibly attainable alternative paths.

Prior to using a technology forecast we need to decide:
i) the extent of projecting past trends as compared to defining future objectives;
ii) the extent of considering technological alternatives; and

Technology forecast: We have already studied technology forecast in unit 4.

Social descriptions/social forecast: Since the core purpose of TA is to examine the effects of technology on society it is appropriate and necessary to describe the society in which the technology exists or will exist. There are various ways of describing society, viz.:
a) The state and stability of society (war, no political upheavals etc.),
b) macro indicators such as characteristic of the economy in terms of industrial/agricultural/services shares, income and its growth, population as characterised by male; age and educational profile etc.
c) specific descriptions of aspects such as. percentage of children in the population, percentage of people in a certain income group, literacy, etc.

Some experts suggest that there should also be a description of the symbolic elements of society that the policy makers are trying to achieve or goals they have set for themselves e.g. decentralization, panchayat level planning etc. Social forecasting is extremely difficult and complex and there are very few models that could be advantageously used. The two most used approaches are cross-impact analysis and scenario construction, though they have their limitations.

Impact identification, analysis and evaluation: It mainly consists in identifying, analysing and evaluating the impacts of the specific technology. It is thus concerned with producing knowledge to assess the range of consequences that will result from particular technology development. It also involves performing a comparative evaluation of the technological alternatives using broad-based criteria such as social, cultural, political and environmental concerns along with more conventional concerns such as technical performance, economic, legal and institutional considerations. The selection of criteria by which the impact of technology is assessed is a critical step in performing TA since, in a sense, it pre-focuses the entire impact assessment effort. The impacts identified are then rated according to their importance so that the impact field could be within manageable levels. The importance of impact and the criteria followed could vary in terms of significance for the policy makers, the affected groups, the political system etc. This should be clearly specified. Each of short-listed impacts including the second order impacts are analysed in terms of their significance, probability, timing, costs, affected parties etc. This could be, carried out in the following ways:

a) **Scientific analysis:** Subject wise experts, are employed to conduct and analyse the impacts in their respective fields e.g. economic impact, environmental impact, psychological impact etc.
b) **Interdisciplinary and futuristic analysis:** This covers a large range of fields and involves systems analysis and futures research. Some of the common techniques used are; expert opinion, cross-impact analysis, scenario writing etc.
c) **Social impacts analysis:** The emphasis is on a broad set of social impacts identified for each of the short-listed impacts. The common techniques used are expert opinion, polling, morphological analysis etc.

The last stage is evaluation of impacts. This basically entails the assigning of values to specific impacts, e.g. degree of environment non-pollution for a fertilizer plant project could be assigned a higher value than the profitability, etc. The values assigned are largely dictated by the bias of the evaluator, and/or the sponsor or the social group it represents. But the primary concern is to enhance the objectivity of the TA. One of the ways to achieve this is by involvement of the stakeholders (interested parties) in the evaluation through conferences, polls, public reviews, interviews, direct participation in the evaluation team, etc. To some extent impact evaluation is implicit in initial stages of TA as well. At this initial stage itself the underlying assumptions/biases are made explicit. Several techniques are available for evaluation of impacts, e.g. dimensionless scaling, decision analyses and policy capture.

Policy Analysis: The policy analysis consists of two levels: the first level deals with specific policy options and is carried out in four steps: (a) formulating feasible policy options through which to implement each of the technological options, (b) comparative analysis of the policy options by using the impact assessment and evaluation, also listing therein second order and perceived impacts, (c) synthesizing the best or optimal policy or combination of policies and the strategies for implementing each technological alternative and (d) presentation of a summary comparison of the selected optimal policy options and a comparative evaluation of the advantages and disadvantages of each policy option. It may not always be possible to follow these four steps as application of one or more technological alternatives may extend beyond the scope of policy thrust itself.

The second level policy analysis deals with identifying and assessing general circumstances, obstacles, concerns and conflicts that might be associated with the technology alternatives. However, the outcome of policy analysis should be to provide the decision maker with fairly substantial, realistic and objective description of the various available alternatives, their implications, and their feasibilities.

Communication of Results: Effective communication of the conclusions/ recommendations/results of the study is essential to the success of TA itself. The objective of the study is to present the results in a manner that is comprehensible to the diverse constituencies, the decision makers, the stakeholders and the public. The decision-makers have to be informed of the implicit trade-offs between future and present costs/benefits/impact etc. A communication barrier may nevertheless arise with the decision-maker as he may be unwilling to assume the risk which may be assigned to various policy options. Communication to public may pose problems as most TA studies deal with potentially controversial issues. Lastly communication within the study team on the revision of definition of the task etc. is also important.

8.5 ORGANISATION AND MANAGEMENT OF TA

Given the complexity of the TA and its broad interdisciplinary coverage the organisation and management of the TA study itself is included as a part of the TA activity. Two features identified with respect to TA study are structural and process details. The structural features include project team, its composition, and leadership, selection of techniques, hierarchical set up and whether the study is tarried out as interdisciplinary or interdepartmental work, the budgetary resources etc. The process features include project scheduling with milestones, communication pattern among project team and its integration, especially among the members from different disciplines. Although these features are well stated in theory the TA in practice is often undertaken on an ad hoc basis.

8.6 TA IMPERATIVES

TA attempts to assess the effects in future of technology development and its introduction on society are inextricably linked to forecasting. TA thus attempts to obtain scenarios of future developments of both technology and society and their mutual interactions. The key! words for success of TA are neutrality, unbiasedness and objective analysis on the part of the study group, and their presentation and interpretation of results without any fear or favour. But it is not easy to confirm these qualifications of TA as the collection of real life database for TA is very difficult. Braun has described why this is so:

> The database for Technology Assessment does not consist of laboratory observations obtained from immutable nature according to strict rules. Instead, it consists of a complex web of fact, conjecture and opinion obtained from a wide range of written and oral sources. Different assessors have access to different sources and often, alas all too often, the data available are but the tip of the iceberg of secret information; secret because of commercial or political or personal confidentiality or simply out of the convenience of the cabal. Such information is largely inaccessible to the analyst and often even the knowledge of its existence remains hidden. We must accept that the database for a TA will be incomplete and variable according to the methods and possibilities of collection and selection by different groups of analyst.

Due to these difficulties a certain amount of subjectivity is inevitable in any TA study. TA is an ideal: strive as we must, the best we can achieve is a gradual improvement in our understanding of the effects of technology and thus better control and mastery over it. TA has now reached a level where it is an accepted technique to arrive at meaningful and useful policy analysis. Thus TA needs to be used increasingly by decision-makers in developing countries to choose appropriate forms of technology keeping in view their national/organisational objectives/goals, e.g. self-reliance, fulfillment of basic needs, poverty alleviation, enhanced employment generation, environmental soundness etc.

In forward looking very large corporate organisations in developed countries, TA is sometimes undertaken as a continuous exercise in order to remain competitive. The findings of this exercise are used as inputs to the planning process and decision-making in general. At the national level, in India, there have been sporadic attempts at TA from time to time; it is only recently that the Technology Information, Forecasting and Assessment Council (TIFAC) has been set up in the Department of Science and Technology. It has initiated studies related to TA in India. It is hoped that these efforts would be useful to the policy makers in the newly emerging policy environment.

Activity 1

Are you aware of any TA study that has been done in India? In what way did it help influence the decision-making process? (You may like to talk to some knowledgeable people in technology research organisations, e.g. Department of Science And Technology, Department of Scientific and Industrial Research, Council of Scientific and Industrial Research, Centre for Development of Telematics, etc.)

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8.7 TECHNOLOGY EVALUATION

In India the formal acquisition of technology, through licensing or purchase, has been rather small. Indigenous technology sources such as NRDC, CSIR, ISRO, DRDO, AEC, DOE, DST, collectively license no more than 400-500 parties in a year and import of technology accounts for a similar figure. In most cases technology is acquired through informal mechanisms such as mobility of persons, reverse engineering etc.

Technology evaluation as a formal tool has not been applied or used in most cases of technology acquisition in India. But with the integration of the Indian economy with the global economic and trade systems, industrial units in India would need to be globally competitive. For exports not only product specifications arid quality but also manufacturing practices and facilities would need certification and accreditation. This would require that the entrepreneurs carefully select the technology to be adopted. The first step in this direction is technology evaluation (TE). TE is a firm/ organisation level exercise of choosing a technology from amongst a set of available technologies, the adoption or use of which will optimise on a set of defined parameters. These technologies may be available from abroad, within the country, or even developed in-house by the firm/organisation. TE thus differs from TA in that:

i) TA is a macro level exercise and seeks to look at the effects of a technological development on society and more specifically on special groups etc., whereas TE' determines the effects of adoption of a technology on or with respect to that firm only.
ii) In TA the effects or their quantification is not predefined, whereas in TE the technologies are to be compared on the basis of known/defined parameters.
iii) TA is often more concerned with secondary or unintended effects while TE is more concerned with direct or primary effects. Once again, like TA the difficulty lies in obtaining authentic data and information about a technology. Unlike TA one needs to obtain commercial data on the operation of a technology because the final decision in TE most likely to be a commercial one. There is thus not much academic or formal lit; nature on TE as it is a firm/organisation level exercise and seldom do firms seek to publicise the outcome of their studies. Most often the information pertaining to a technology is obtained from the licensors or other sources under a secrecy agreement and thus cannot be made public. The process of and interface between Technology Assessment and Technology Education; has been presented in Figure 8.1.

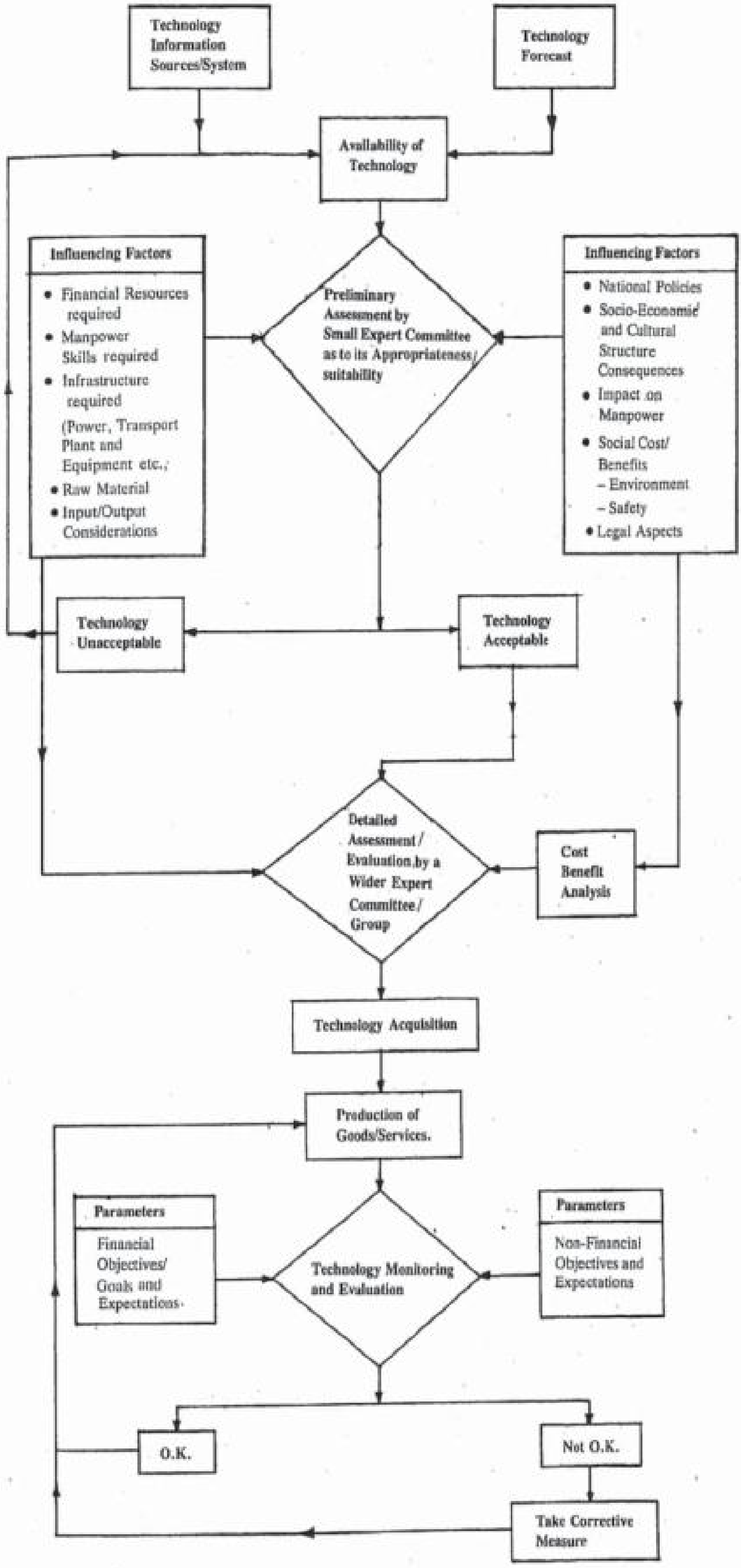

Figure 8.1 : Process of Technology Assessment and Evaluation

8.8 TE PARAMETERS

The basis of evaluation of technology generally takes 'into account factors such as ease/cost of technology acquisition, level of development and the sophistication of technology, size of capital investment and its scheduling, rate of return on investments, break even point, pay back period, sensitivity index with respect to diverse input/output parameters, nature of pollution caused and cost of control, type of capital goods/taw materials required, their availability and imports, manpower skills required and their availability, quality control, exportability of products/ technology, hazards and risks involved and their management costs, rate of obsolescence of technology and technology replacement costs etc. It is obvious that these factors are locale specific. The technology evaluation norms thus would vary from place to place. It technology evaluated by a firm in USA and India need not have the same weightages for specific evaluation parameters and sometimes may not involve even the same parameters. Consider for instance the evaluation of a technology for making S.G. Iron Castings in India and in USA. The nature and cost of pollution control measures would be vastly different in the two countries. In India it may not even be considered as a major parameter. The level of sophistication of technology would have different interpretations in the two countries. In India a semi-automatic system would be preferred whereas in USA the preference would be for a fully computer controlled and automated line.

An organisation at the initial stages of technology evaluation has to determine and decide on the parameters against which the competing technologies have to be evaluated and ascribe relative weightages to these parameters so as to arrive at a single value/index which could then be compared for different technologies. Even two firms in the same country evaluating technologies for the same final product may not ascribe the same weightages to different evaluation parameters. Once again let us take the case of S.G. Iron Casting technologies being evaluated by (a) an entrepreneur seeking to set up a small-scale unit (SSU), and (b) an existing large-scale pump manufacturer (LSU). The SSU would seek technology that is more labour intensive, requires less of capital investment per tonne of output and is within the capital resources of SSU is simple and easy to operate by unskilled operators, is capable of quality control based on manual testing;, whereas the LSU would prefer a technology that is comparatively less labour oriented, has automated and instrumental quality control and high throughput. Thus the parameters and weightages for TE would differ between these two.

Thus every enterprise would need to evolve and lay down its own set of evaluation parameters and based on its resources endowments ascribe a weightage to them. It could then compare the available technologies based on these parameters and the relative weightages.

Activity 2

Arrange a meeting with the Head of the Technology, Engineering or R&D) department or division of your organisation or any other organisation about which you have some knowledge. Discuss with him:

i) How a particular technology was evaluated before it was acquired?
ii) How is the technology evaluated after it has been acquired? Does any regular procedure exist? Are technology pre-acquisition and technology post-acquisition findings compared?
iii) What benefits have accrued to the organisation making technology evaluation exercise?

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Activity 3

DSIR in the Ministry of Science & Technology in India has attempted to prepare reports/studies on Technology Evaluation for some industries or industrial products. Obtain any one of these reports and analyse with respect to its usefulness in the context of your own organisation or any other product/sector with which you are quite familiar.

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8.9 SUMMARY

Technology assessment attempts to assess the future effects of technology development/induction on society and is thus inextricably linked to forecasting. TA also attempts to obtain scenarios of future technology and society and their mutual interactions. The key words for success of TA are neutrality, unbiasedness and objective analysis on the part of the study group, and their presentation and interpretation of results without any fear or favour. But this is not easy. We described the methodology of TA and the stages in that process. How to organise and manage TA was also discussed.

TA is really a macro level exercise and is generally carried out by the government and by public interest organisation. The importance and role of TA in India is yet to be appreciated. Technology evaluation is mostly a micro level exercise relevant to the enterprise in the context of acquisition and development of technologies. TE relates to the evaluation of the effects of the adoption or use of a technology and its performance. The evaluation parameters and norms vary from place to place and include factors such as economic factors, environment and safety factors; societal and labour implications etc.

As TE is mostly firm based there is no significant documented literature on it. The Department of Scientific and Industrial Research, Government of India, has commissioned several preliminary post-mortem studies on comparison of technology in use by several industries. They car'y in them the needs of TE but are not really full-fledged TE exercises that a firm would carry out as they lack cost/economic data etc.

8.10 KEY WORDS

Technology Assessment: TA is the process of taking a purposeful look at the consequences of technological changes, particularly in the context of long-term objectives at national and societal levels.

Methodology of TA: Various methods used or available to make TA at national level.

Morphological analysis: It is one of the techniques used to analyse the social impact of the technologies in the context of conducting TA studies. It related to the analysis of data/information concerning the morphological changes.

Techniques for evaluating impact of technologies: There are several techniques available to examine the impact of technological changes, which are helpful for TA process. These techniques include dimensionless scaling, decision analysis and policy capture. These techniques are however more relevant for national level planning on long-term basis.

Technology Evaluation: Process of evaluation of the effect of the use of a technology and its performance prior to its acquisition

TE Parameters/Characteristics: Parameters or characteristics that can be used for TE and input/output ratios, costs, productivity, manpower skills, raw materials, import-export, environment and pollution control, energy requirements etc.

8.11 SELF ASSESSMENT QUESTIONS

1) Define Technology Assessment (TA). Do you think it is relevant for an enterprise?
2) Briefly discuss the methodology of Technology Assessment, and compare various definitions of the stages involved in the process of TA.
3) The organisation and management of TA is one of the functions of Technology Management Group in an enterprise/corporation. Comment.
4) Do you think that TA could have assisted in better/quicker public acceptance of some programmes/activities undertaken by the Government? If so, which ones and explain your reasons.
5) What are the stages commonly accepted in a TA exercise? Discuss the same with example.
6) Could you attempt a societal forecast of the description, size nature of `middle class in India (say in the year 2000)?
7) What are the objectives of Technology Evaluation & Demonstration programme of DSIR? Do you think it is a useful programme for the industries? Comment.
8) What is meant by Technology Evaluation? Why is it necessary for a company to undertake TE if it wants to import technology or undertake modernisation or diversification?
9) Is it necessary for an enterprise to make Technology Evaluation (TE) exercise? If so, at what stage and why?
10) What are the parameters or characteristics that should be examined or kept in mind while doing TE for a company?
11) What could be the advantages of TE to an enterprise? Would such an exercise improve the competitiveness of the enterprise? Give an example that you know of.
12) Do you think that the efforts made and expenses incurred by an enterprise in TE exercise are worthwhile and can yield adequate returns? Explain.

8.12 FURTHER READINGS

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NIT 9 DIFFUSION

jectives

ter studying this unit you will understand:

- the concept of diffusion
- ts importance in taking technological innovation to the market place
- the different perspectives on the innovation-diffusion process
- letails of various activities necessary for a successful diffusion process.
- the development of a diffusion strategy

ructure

.1 INTRODUCTION: THE CONCEPT OF DIFFUSION OF TECHNOLOGY

he success of a technological innovation depends on the diffusion of the innovation those who can best make use of it. The term diffusion refers to the spread of a new lea (product, technology, service, or method) from the time of its invention or reation to its ultimate adoption by an increasing number of users, in different ircumstances.

Diffusion involves special types of communication methods or system to help diffu hanges in practice, as well as changes in knowledge or attitudes. Thus, diffusion is he process of closing the gap between what people do not know and what they can ffectively put to use. The process is complete when:

- a sufficient number of customers are using the innovation to pay back the amount used to develop it
- it starts to make a profit
- a system is in place for assessing the need for changes to ensure the longevity of the technology.

We have studied about invention, innovation, technology, and technology transfer in some of the earlier units of this course. Technology diffusion is closely related to these topics, particularly to innovation and transfer to technology. It facilitates process of technology transfer by acceptance of innovation on wider scale, for better returns, to the owner or supplier of technology. Diffusion of innovation or technology is more relevant to publicly funded R&D organisations and academic institutions which are generally engaged in basic and applied research and which, by themselves, are not in a position to commercialise the innovations. These innovations may be in public interest in the widest sense of the term. Also, there are highly innovative research companies or small firms in advanced countries who sell their innovations/technologies to large corporations which have adequate infrastructure and capability to commercialise the same. Large corporations do not generally diffuse their first generation technologies or innovations until the latter have not matured or have become practically obsolete in their native markets. They think of diffusion only after adequate returns have already been obtained on the investments.

In India, attempts are made to diffuse inventions, innovations and technologies generated in national or publicly funded R&D organisations and academic institutions through technology transfer agents and other channels of communication including such organisations themselves. Many organisations, such as Indian Space Research Organisation (ISRO), Atomic Energy (AE), Defence Research and Development Organisation (DRDO), Council of Scientific and Industrial Research (CSIR) have set up their own mechanisms to diffuse their innovations and technologies. Recently, Indian Institute of Technology (IIT), Delhi, has also set up a foundation for innovation and technology transfer. The manufacturing companies in India generally are not in a position to diffuse because their technologies have been acquired from external sources. The situation in India or several other developing countries is quite different from industrialised countries in so far as diffusion of innovation or technology at the firm level is concerned.

In this unit, we shall study the process of technology diffusion, particularly relevant to innovation firms and market oriented research organisations. Technology diffusion is an important activity in the management of technology at national and enterprise levels.

9.2 THE IMPORTANCE OF DIFFUSION [1]

Making the most of technological innovations should be an explicit goal of each corporation — a goal reflected in a continuous set of action steps. Broad diffusion of a technological innovation does not just happen; it must be managed.

Companies that sell technology to one or two types of customers must take time to diagnose the needs of other potential customers. In addition, companies must attempt to diffuse their domestic technology into foreign markets by adapting them to different needs. For instance, a company that makes telephone switching equipment for temperate climate and conditions of stable power supply should adapt the technology for tropical climates and unstable power supply conditions.

A technological innovation can have a long life if management views it in the proper way. A technology that becomes obsolete in one market may still be considered new in another. For example, some of the technologies that India has been obtaining from abroad in high-tech areas like computers and communication are technologies that have outlived their life in their own markets but are still found to be attractive here.

Several models for diffusion of innovation have been proposed by various specialists/experts in the field (Nawaz Sharif, 1983). These include Coleman Model, Dodd Model, Mahajan-Schoeman Model, Sharif-Ramnathan Model, and Polynomical Model. All these models involve certain assumptions of varying degrees and advanced mathematical computations. A deep study of these models is beyond the scope of this unit. It may however be mentioned that these models are highly theoretical in character. Their practical utility is doubtful even for R&D organisations or firms in the developed countries.

As mentioned earlier, in development countries such as India, the technology diffusion is generally considered important for R&D organisations and academic institutions which are engaged in development and transfer of technologies. A well managed technology diffusion system enables an organisation to plan its technology development projects in a more meaningful manner as well as transfer the technologies more successfully. Such an approach results in better returns for the investments made in R&D and technology development systems. At times governments are also keen to promote diffusion of technologies having social or strategic importance such as for energy conservation, pollution control or environment friendly technologies such as family planning and population control methods, better utilisation of scarce natural resources, and so on.

:he firm level, the need and importance of technology diffusion is directly related :s innovative capacity and the levels of technologies developed. In India, such an ɔvative capability, or management policies in this direction are not much in lence as most of the firms are often engaged in development or acquiring of ınologies relevant to their manufacturing activities only i.e. for captive use.

wever, there are cases of transfer of technologies by Indian firms to other 'eloping countries. A well managed technology diffusion system becomes ɔortant for such firms. With the increasing emphasis on exports, there will be a ater need for adopting better planned technology diffusion system on the part of firms, and hence technology diffusion would assume greater importance in the es to come. The innovative firms or firms engaged in higher level of research on technological spectrum will have to plan appropriate strategies for identifying ernal markets, for horizontal transfer of technologies, and for technologies ɾeloped by them which are not relevant to their direct manufacturing activities.

9.1PERSPECTIVES ON DIFFUSION[2]

ere are several perspectives on diffusion, some of which are discussed below:

aditional Perspective

chnological innovation and diffusion have traditionally been viewed as separate ɔcesses. This view treats diffusion as the marketing efforts required to expand the ceptance of the technology beyond the markets initially targeted. This limited entation prevents management from perceiving what employees can do at each ge of the total technology development process to affect the eventual diffusion of : technological innovation. Successful diffusion requires a comprehensive rspective on the technological innovation/diffusion process. This perspective can en serve as the basis for a cohesive strategy.

doption Perspective

ie adoption perspective is most often used to describe the diffusion process. This rspective focuses on how the various channels and modes of communication ıedia, interpersonal etc.) can be used to influence a diverse group of potential stomers to adopt a technological innovation. The issues may include how best to epare the message about the technological innovation for these diverse groups, how select the appropriate media mix and how to obtain feedback about customer eds. For example, this perspective is often helpful in diffusion of technological novations like a new method of cultivation or irrigation in rural India where a ajor task would be determining how to convince people in adopting the new chnology.

echnological Perspective

ıis perspective focuses on the technical skills and tools required to implement/use e technological innovation. The technological perspective also looks at how well the ovider of a technological innovation understands the environment of the user and e user's ability to apply the technology and also the ability of intermediate agencies te the government. (Many technology transfers in India, like that of the technology r EPABX have taken place at the initiative of the innovating organisation to the er (through the government).

ıfrastructure Perspective

he infrastructure of the region in which the technological innovation is targeted is ı important factor in diffusing the innovation. Infrastructure aspects that affect ffusion include transportation, terrain, weather, availability of energy, ɔmmunication, etc. Poor infrastructure development can constrain some novations. Diffusion will occur only if the necessary facilities exist.

ɔr example, poor access to maintenance and repair service at acceptable costs ɔnstrain the adoption of information technology in maintenance of land records, primary health care centres etc. The application of biotechnology to agriculture will require building infrastructure like distribution and service networks and teaching farmers and others how to use the new techniques. In this case, diffusion will most likely involve some combination of agents, including government, cooperatives, private distributors, and many others—most of whom may be beyond the direct control of the biotech firm. In order to develop a successful diffusion strategy the diffusing organisation must consider all these aspects in conjunction with the infrastructure that is available.

Regulatory/Societal Perspective

The regulatory/societal perspective looks at the effects of government policies, regulatory requirements, and bureaucratic processes, and the development stage of the area in which the technology is to be used. This perspective is particularly important for diffusion of technologies in developing countries. Regulatory requirements affect the ability of potential customers to adopt innovations as well as the ability of a diffusing company to compete with other companies. For example, technologies that are capital intensive may not be encouraged by governments which are interested in pursuing a policy of employment creation through labour oriented methods. Companies may not want to part with their technology to countries that do not provide adequate patent and copyright protection (intellectual property rights). Similarly, societal issues like consideration of a technology mostly for elitist living can affect the diffusion of a technological innovation (e.g., car phones).

Models Perspective

The models perspective looks at the development of models that management can use to predict the behaviour of potential users of a technological innovation and, consequently, develop strategies for diffusing an innovation. To model a diffusion process, an analyst works with a few variables to fit a curve that describes the spread of innovation over time. These parameters might represent the size of the population, number of alternate technologies in use, complexity of the technology etc. For example, some investigators have analogised a technological innovation diffusion process to the spread of an epidemic through a population and have accordingly used one or another of several epidemiological diffusion models.

Several models for diffusion of innovation have been proposed by various specialists/experts in the field. These include Coleman Model, Dodd Model, Mahajan-Schoeman Model, Sharif-Ramanathan Model, and Polynomial Model. All these models are based on certain assumptions and require advanced mathematical computations. A depth study of these models which are quite theoretical is beyond the scope of this unit. However, with a view to give you a feel of these models, we have briefly discussed the Concave Diffusion Model in the Appendix to this unit.

Comprehensive Perspective

The comprehensive perspective uses all the perspectives discussed so far in developing a diffusion strategy. It views the diffusion process as part of a total innovation process. Many people are involved in the innovation/diffusion process and this view maintains that each person involved with a technological innovation must maintain an interest in it for a much longer time than what is normally spent in developing the technology, and further that he should be available to make the changes that may be required over the life of the technological innovation.

Activity 1

Choose two products whose technology you are familiar with, Analyse the various perspectives on diffusion of technology for each of these products. Do you see any merit in the comprehensive perspective?

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.4 MAJOR DIFFUSION ACTIVITIES[3]

iffusion is a multi-faceted activity. We shall briefly discuss phases of diffusion one / one.

ıdividual Action

he diffusion process begins with the first stage of innovation the individual action age. During the individual action stage, the inventor proceeds (sometimes without ven realising it) through a series of steps that result in practical use of an innovative lea. The innovator may draw on the resources of others, but the effort is essentially ıdividual. This stage includes eight phases, each of which contributes to the ınovation and diffusion process.

) **Creation of Favourable Conditions:** The leadership in the organisation must establish the expectation that everyone will take some responsibility for generating innovations and make some contribution to their diffusion. In return, the people in the organisation should expect that they will be rewarded for their efforts. The employees must also believe that they can generate innovations and can spot opportunities for innovations for the benefit of the company.

i) **Identification of Unfulfilled Needs:** Employees should be on the lookout for people's needs that can lead to the modification of current technologies or to the creation of new technologies.

ii) **Definition of the Problem:** Marketing must test the needs that it perceives against the reality of user needs. People in marketing should translate their perceptions of need into terms useful to people in development; those in development should translate what they see into terms useful to research; and those in research must translate their findings into terms useful to development and marketing as each individual seeks uses for possible new technologies. Each individual from ever function can thus participate in the innovation process in some way.

v) **Preparation for Problem Solving:** Gathering information about a need— how widespread it is, what others have done to solve it, what solutions have not worked and what consumers really do want—is part of the preparation for solving a problem. All the capabilities of the company should be used in this preparation, including the patent office, the library and the organisation's technological and marketing gatekeepers. Most studies of modern management emphasize the need to wander around among users and consumers to find out what their needs are.

) **Incubation:** This phase is usually a most private affair. All that an individual can do is to recognise that each person will have unique conditions that stimulate ideas. People must learn to respect the range of circumstances that others find useful for innovative/creative thinking and resist efforts to impose conformity at this phase.

vi) **Inspiration:** Individuals are usually exhilarated when they have struggled with a problem for some time and finally come up with what they think is a solution. They need all the momentum they can achieve to carry them through the more tedious steps of gathering technical and market feasibility data before proceeding. Supervisors and co-workers should learn how to mirror some of their colleague's enthusiasm instead of doing what most people do — finding a way to prick the bubble of excitement.

vii) **Externalisation:** Preparing the idea for others to evaluate and develop is a crucial task, since inadequately prepared descriptions are apt to be rejected. Management should help people prepare their ideas for presentation within and outside the organisation.

viii) **Influence:** Most ideas have political aspects. Once an idea has been prepared for review, knowing whom to influence, when to influence, and how to influence people within the company becomes important. Very often those who are most able to generate solutions to problems are least able politically. Those with political experience should be ready to help with advice.

Applying Basic Research

This stage represents the translation of the findings of people who have done the basic research (people) into applications. The applications of basic research is a more organised effort than individual action. The disciplined activities of specialists are focused on seeking orderly explanations of phenomena and practical applications of that knowledge. However, the roles of the individuals are critical throughout the process.

Diffusion during this stage requires an understanding of how various disciplines and functions interact with each other. This interaction may occur as a result of either mission-oriented research or the interaction of people in different disciplines trying to solve problems in their own areas.

Diffusion at this stage involves linking the basic scientist's work to the applied scientist's work and the world outside the laboratory through the **Comprehensive diffusion perspective**. Applied scientists have a responsibility to keep abreast of consumer problems that need solution. Basic scientists need to describe their findings in ways that allow applied scientists and marketing people to visualize market possibilities. Many successful basic research scientists take the opportunity to visit the field to see what is going on.

Improving the linkage between R&D and marketing is highly related to successful — continuous and timely — diffusion efforts. Lack of communication can cause many problems. An inventive scientist may develop a new way of making bricks and constructing houses from the fly ash of thermal plants, but may not get feedback about the market's acceptance of the idea. The lack of feedback may cause him even to leave the company and abandon his idea.

Even though basic research people have a legitimate need to follow their own leads, unencumbered with the need to consider the social utility of their findings, they cannot avoid thinking about the probable impact of their work upon society. The movement of an idea from the world of science (i.e. the laboratory) to application is a critical process. The innovative organisation must make special efforts to prevent an idea from dying at this stage and to cut the time required to pass through this interface.

Industrialisation

The third stage of the innovation process is the industrialisation stage. The industrialisation stage focuses on developing a practical and profitable application of the technology. It links customer demand with technical opportunities and out of this emerges a design concept for evaluation. Linking technical opportunities with market demand requires coordination and cooperation among applied scientists, engineers and marketing personnel, especially market research personnel. The joint efforts of many people from many functions, including personnel from R&D, marketing, corporate development and planning, and new product development, can best generate the initial product concepts.

During this stage it is wise to keep in mind the company's capabilities and strategies when looking for relevant customer needs that make use of these capabilities. The company should formally re-examine and restate its capabilities from time to time, since these often grow incrementally as the company acquires the ability to cope with threats and opportunities. For example, some of the computer graphics technology that Centre for Development of Telematics (C-DOT) at New Delhi develoced for its switching applications was also found to have wide applications in railways and defence.

If the concept survives the needs assessment, the organisation may choose to implement the innovation or it may adopt someone else's innovation. Knowing that other firms have done is therefore an important input to the creative process at all phases of innovation. The firm can sometimes acquire an innovation and adapt it at less expense than it would take to develop one, internally, from scratch. During this stage a limited target market segment (possible user group) is selected for tryout. During this initial commercialisation effort the firm can locate and correct the flaws in preparation for full commercialisation.

fter initial development of the technology concept commercialisation receives the ajor emphasis. The boundary between the industrialisation and commercialisation age is hard to define exactly. Commercialisation includes finding solutions to all the oblems of defining the technology, organising trials, mechanisms for transfer of chnology and expanding and managing the technology life cycle.

relaunch activity marks the beginning of this stage as a small-scale pilot test gets nder way and the first customer trials begin. The next major activity is the launch of e innovation trails. During such trails, the organization can assess technology cceptance, alter methods of transfer, check manuals for ease of understanding and e like.

ommunication activities are the next major events. The marketing department evelops a description of the attributes of the new technology, selects channels for its arketing message, and begins development of a promotional programme. Marketing next assesses the target market segment to identify the potential adopters hat should be influenced first. The firm next develops the corporate capabilities for anaging the diffusion, setting pricing policies and selecting and segmenting the narket as a whole.

Commercial development of innovation takes place next. Diffusion activities now ocus on spreading the net by acquiring more adopters. Usually the next step, once ufficient customer demand indicates continuance, is transfer of the technology to an perating division. Diffusion methods used in this transfer are especially important. Once an operating division launches the technology, it must maintain it. The division nust assess signs of decline or changing consumer preferences and take corrective action.

Full Scale Diffusion

This is the last stage of a comprehensive innovation/diffusion process. It includes a search for a wider range of potential markets, new industries new geographic regions, new market segments that have not been explored, and new ways to couple the innovation with other innovations. The way that electronics and computers have diffused throughout the industry and the world is a prime example of full scale diffusion.

Activity 2

If you have been involved in any phase of the diffusion process described in this section, analyse how the activities described in the text relate to your own experience. Suggest ways of improving the diffusion process in your organisation based on what you have learnt in this section.

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9.5 DEVELOPING A DIFFUSION STRATEGY : TAKING THE TECHNOLOGY TO THE MARKET PLACE[4]

Developing a diffusion strategy involves a number of activities and many people. This section looks at each of these activities separately but in a real situation many of these activities may go on concurrently. Some people in the organisation will participate only at certain stages, while others will have continuing roles. Thus, the development and implementation of a diffusion strategy requires effective management.

Assess the Organisational Climate: An important factor related to successful diffusion is an organisational climate that supports diffusion and innovation objectives. To facilitate this it will be useful to list a set of organisational attitudes and objectives that can support the innovation and diffusion process.

These objectives could include the need to orient to the future, for timely action, to anticipate changes, threats, and opportunities, and for all members of the organisation to play a role in launching an innovation. In addition to communicating these objectives throughout the organisation management must initiate programmes an practices that make these objectives a living force.

Studies of successful diffusion show that one of the most consistent features is the presence of dedicated people who persist in their efforts. Such people are called "technology champions" or "change agents". How well an organisation nurtures such people and understands and supports the process is an important element of the organisational climate.

How management structures and controls the organisation has a profound impact on the diffusion process. There has to be a balance between a centralised decision making structure and decentralised operations. The number of layers through which a new technology idea must be cleared before it can be implemented has a significant impact on the speed with which the diffusion can take place.

Leadership style also affects the diffusion strategy. If the style is authoritarian, dissenting voices may not be heard and assenting voices may be amplified. But the organisation can take quick action. If the style is too participatory, the action may be slow but major mistakes can be avoided. The ideal would be a leadership style that is clear and gives urgency a high priority.

Understand the role of "Technology Champion": The change agent or technology champion must play a bridge role within and outside the organisation. Within the organisation the change agent should provide communications between the marketing and the R&D organisation. In market driven organisations, the main directions for technological innovation come from marketing. R&D's reaction comes in the form of guidance on what is technically feasible and ideas from scientific circles.

A technology driven organisation offers a marked contrast, as R&D drives the stimulus and marketing officials must find applications. These efforts can help create new markets by applying technological breakthrough to largely unperceived needs. In India, technologies and products are mostly market driven while in industrialised countries markets are mostly technology driven.

When introducing a new technology to potential customers outside the organisation the change agent must explain the need for the technology. Demonstrations, films, or other techniques can help the customer to become aware of the need for the new technology. The change agent must show real interest in the user's problems and prove it in his or her behaviour. Should the firm invest in a technology suitable for production of large volume of communication cables when the customer wants to produce a limited quantity of cables only? The change agent should be sensitive to the users' needs and help the user to overcome problems he encounters.

Define the Profile of the Technological Innovation: Different types of technological innovation require different diffusion efforts. If the technology is new to both the market and the company, adopters of the technology have to be educated on its use. Diffusion efforts may have to overcome resistance to the complexity of the technology (as with fibre optics) or social or cultural barriers (birth control devices). In contrast, if the technology is a modification or improvement of an existing technology (Example: energy saving process), diffusion efforts must stress the superior attributes of the new technology.

Use Opinion Leaders: An important part of the diffusion strategy is the identification of opinion leaders, assessment of their orientation (towards acceptance or rejection), assessment of their scope of influence, and development of ways to influence them. Such leaders influence opinions and actions in informal ways. They are people or institutions whose information and opinions are sought on subjects in which they are considered experts. They are technology gatekeepers and feel qualified to evaluate a technology and market gatekeepers who feel qualified to scribe what people want to buy. Their influence is often extensive because they nd to have a large number of acquaintances and because they play the role of inging people of related interests together. A good example is the position that rious individuals and organisations took towards C-DOT's switching technology.

hange agents must develop strategies for reinforcing those opinion leaders who vour the innovation and technologies and reducing the opposition of those who are gative. Assessing the ratio of positive to negative opinion leaders and their relative fluence is also important.

evelop a Communication Strategy: Developing a communication strategy is one of e major tasks of the diffusion process. To achieve successful communication, the ganisation must relate the innovation's attributes to customer needs. If an analysis the user's situation and capabilities indicates that service may be a problem, then ommunications should describe how service will be provided. The change agency ust show, through its communications, that it wants to be useful by meeting istomer needs and that it is willing to learn from its customers. The company's essages must also prove its reputation for reliability, honesty, and oughtfulness—in fact, what the company communicates about itself is almost as nportant as what it communicates about the innovation. For example, Motorola, a S based semiconductor and communication company which is trying to introduce ellular technology in India, considered elitist (in some quarters), has been dvertising extensively in the media portraying it as a technology for development of ıral India.

ommunications: Two areas of communication are within the organisation (internal ommunication and with agencies outside the organisation external communications.

nternal Communication: Successful communication leads to action and many ctors affect success in the communication process. The innovator or the innovating roup must describe the innovation in terms that enable others to work on its behalf. hus, facilitating communications between R&D and marketing is a continuing ianagement task. The message to internal corporate decision-makers should include alistic estimates of the initial resource requirements, staff, time, and money quired to launch the innovation.

company's system for processing innovations can smooth and speed the flow of the iffusion process during the internal stage. Such systems use standard criteria to idge innovations, give feedback to the source, and identify the product champions ho will nurture the innovation to successful commercialisation. If the originator nderstands how the development process works and is aware of the problems sually encountered at each stage, he or she can often help overcome the difficulties r suggest ways to capitalise on the strengths of the innovation.

xternal Communications: Once a technological innovation is transformed to a rototype or a sample for field trial, the focus of the diffusion effort changes from nternal to external communication — getting the word to potential adopters. The ontent of the message is largely guided by the:

a) attributes of the innovation, and
b) the characteristics of the target market of the technological innovation.

Attributes of the Innovation: It is widely recognised that five general attributes of innovations are useful in preparing messages: (i) relative advantage, (ii) compatibility (iii) complexity, (iv) testability, and (v) visibility. To convey these attributes to potential adopters, the change agent must discover what the customer seeks, thinks, and feels.

i) **The relative advantage** of a new idea helps determine its rate of adoption. The factors that affect the perception of the relative advantage, and which are however, important parts of the message, include the innovation's comparative cost, the savings in time or effort it provides, and how soon it is available (most companies want it as soon as possible). Companies can reduce the perceived risk of trying an innovation by offering performance guarantee (like yield for a new process). Societal factors may also affect the customer's perception of relative advantage. For example, the oil crisis increased interest in energy saving technologies for automobiles, power generation etc.

ii) **Compatibility** is the degree to which potential adopters see an innovation as consistent with their values, experiences and needs. The organisation should see if the new technology suits the current or evolving customs or beliefs, symbols of acceptance and status, and previously introduced ideas. For example, many organisations that have traditionally been in the low technology engineering sector are diversifying into high technology computers and communication areas as these are supposed to have a higher status in the business world today.

iii) **Complexity** is the degree to which an innovation is relatively difficult to understand and use. Organisations seeking to introduce technologies that are difficult to use or understand must concentrate their efforts on developing simple how-to-use and how-to-understand explanations. The computer industry's emphasis on developing user-friendly menu driven software technology is one example of efforts to overcome user's resistance to perceived complexity.

iv) **"Testability"** is the degree to which potential adopters can experiment with an innovation on a limited basis. Development of such opportunities is an important diffusion activity. For example, modular switching technology not only facilitates absorption it also allows for testing the basic building blocks. This in turn facilitates decision-making on acquiring technology for larger units.

v) **Visibility** is the degree to which the results of a new technology are apparent to others. When digital technology was first introduced for telephone communication the users could clearly perceive a significant difference in the quality of the call; and the adoption of digital technology by telephone companies proceeded at a rapid rate.

These five general categories of attributes are only a sample of those available for use in structuring messages to potential adopters. A firm can run into problems if it uses these categories without careful thought about how they apply to the company's technological innovation.

b) **Characteristics of the Target Market:** To reach business prospects, the message must relate the important attributes of the technological innovation to both executive management and the group in the customer organisation that would actually use it. Discovering the attributes desired by the dominant decision making group in the customer company may well be an important prelude to designing communications to hasten adoption. While including concern for the needs of the actual users at the initial stage may prolong the adoption period but it will increase the endurance of the innovation.

Communication Channels: Two principal modes of communication for message about innovation are the mass media (radio, TV, film, newspaper, magazines) and interpersonal channels (word of mouth, trade shows, demonstrations etc.)

The **mass media** are relatively quick in beaming the message to many people. However, since it tends to be one way, the lack of feedback about customer reception makes the media less effective than interpersonal communication in moulding attitudes to the new technology. This may be suitable for simple technology like food preservation/processing with potential for large number of customers spread over a wide area.

Interpersonal communication has an important influence in promoting diffusion. Particularly in the areas of high technology where there has to be a dialogue between the innovator and the potential customer, a strong relationship exists between understanding a technological innovation and being influenced to buy.

Assess the Life of the Technological Innovation

he life of the technology can be extended by incorporating feedback about the ustomer's reaction to the technology to remedy defects and develop a new eneration of the same technology. The organisation selling the technology can nhance its life by providing opportunities for the users to participate in a network ith other users to observe the application of the technology wherever feasible. A nger life is certain if the innovation meets a well defined customer need that the eller understands. The seller must remain aware of any changes in customer needs nd modifications that would meet those changing needs.

enewal of the technological innovation/diffusion cycle requires a continuous rogramme for reassessing the needs of customers, competitive and regulatory reats, opportunities to serve industries that have not been served, and imaginative iloring of the technology to meet new needs.

Activity 3

Identify, with regard to your own organisation, a technology champion/change agent. Compare the similarities and differences in the role of this agent with that described in this text. Do you consider the change agent to be a success? If so, list the key attributes of a successful change agent. If not, identify the areas that need improvement.

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Activity 4

Pick up a technological innovation that you are familiar with and list the various attributes of the innovation. Identify, the target market and discuss how you would use this information to develop a communication strategy.

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.6 SUMMARY

he development of a corporate strategy for diffusing innovations to target consumer egments around the world requires a comprehensive perspective that views diffusion s an integral part of the innovation process, rather than a discrete activity that takes lace after the development of the technological innovation.

everal overlapping perspectives are currently used for planning for and assessing iffusion activities. The adoption perspective concentrates on influencing the onsumer's decision processes, the infrastructure perspective looks at the physical istribution and communication systems, the regulatory perspective looks at overnment policies and social sanctions, the technology perspective emphasises the chnological content and the models perspective includes the numerous athematical models used to predict the adoption rates. Successful diffusion requires e integration of all these perspectives into a cohesive corporate-wide programme and volves personnel representing many corporate functions and divisions.

he diffusion process is an integral element of the total innovation process, which xtends from the time an idea for a new technology is conceived in the mind of one erson through multiple development and commercialisation phases until it has run its course in the worldwide market-place. A concept needs many sponsors and agents who look out for its welfare if it is to survive to be a value to the optimum number of people. Viewing diffusion as part of the total innovation process highlights many more opportunities for sponsors of an innovation to participate in its diffusion.

Building an affective diffusion strategy, whether for the entire organisation or for a single technology, depends on making full use of the resources available. The climate must be right, people must understand and carry out their proper roles, communications must be carefully planned and executed. The "technology champions" or "change agents" in the organisation are key players in the activity. They, in turn, must understand why some people are immediately drawn to an innovation while others hold back. They have to figure out how to overcome this resistance. Finally, a good diffusion strategy provides for "keeping the innovation new" rather than merely letting the life of the technology run its course.

In developing countries such as India, technology diffusion is presently more important for R&D organisations and academic institutions which are engaged in development and transfer of technologies. There are cases of export of technologies by Indian firms which also need to plan an appropriate mechanism to diffuse their technologies. Most of the firms in India develop or acquire technologies directly relevant to their own manufacturing activities. However, with the increasing emphasis on exports in the times to come, a well-planned technology diffusion strategy would be necessary for innovative firms as a part of the total technology management policies.

9.7 KEY WORDS

Diffusion is the spread of a new idea (product, technology, service or method) from the time of its invention or creation to its ultimate adoption by an increasing number of users in different circumstances.

Technology Champion/Change Agent is a dedicated individual who persists in his or her effort in taking an idea for a new technology conceived in the mind of one person through multiple development and commercialisation phase until it has run its course in the worldwide market place.

Opinion Leaders are people or institutions with extensive influence whose information and opinions are sought on subjects in which they are considered experts.

9.8 SELF-ASSESSMENT QUESTIONS

1) What is meant by diffusion? Why is it important in the context of a technological innovation?
2) "Management should actively work on a marketing strategy for a technological innovation only for expanding the acceptance of the technology beyond the markets originally targeted." Discuss.
3) "Regulatory/Societal Perspective is particularly important for developing countries." Discuss by means of suitable examples.
4) "Poor infrastructure development can constrain the diffusion of some technological innovations." Discuss by means of suitable examples.
5) "Improving the linkage between R&D and marketing is highly related to successful diffusion." Discuss.
6) What are the major activities in the industrialisation phase of technological diffusion?
7) List some of the organisational attitudes and objectives that can support the innovation and diffusion process.

) **Define a change agent. What is his/her role in the diffusion process within and outside the organisation?**

) **Discuss the role of opinion leaders in developing a diffusion strategy.**

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Appendix

Concave Diffusion Model

It was mentioned in the unit that several formulas for studying the diffusion and adoption of technology are available. For example, one of the diffusion models is called the Concave Diffusion Model which was developed by Louis A. Fourt and Joseph W. Woollock. This model is based on the observation that the cumulative curve of market penetration approaches a maximum penetration level of less than 100% (frequently far less) of the market for the technology. This model assumes that the increments in penetration for equal time periods are proportional to the remaining distance to the "ceiling" (maximum) penetration. Thus, successive increments in penetration gain decline over time.

To use this model, the planner first estimates the total potential for the technology, using market research studies of the percentage of individuals or organisations who express a strong desire for or interest in the technology. The expressed desire to adopt a technology is often related to the ultimate acquisition of the technology, but it is necessary to differentiate between those who desire and acquire and those who desire but do not acquire. The planner also makes an estimate of the penetration rate, based on how fast potential buyers are likely to learn about the new technology, to acquire the technology and then what proportion of those who say they are interested actually acquire.

In this model the increment in penetration for any given period is given by:

$Q_t = r\bar{Q}(1-r)^{t-1}$, where

Q_t = the increment in cumulative acquisition of technology (i.e., the number acquiring the technology in period t) as a fraction of the market size.

r = the rate of penetration among the untapped potential customers (constant)

$\bar{Q}$ = Estimated potential for the technology as a fraction of the market

t = the time period (1,----, n)

The behaviour of 'Q_t' with respect to 't' is shown in Figure 9A.1

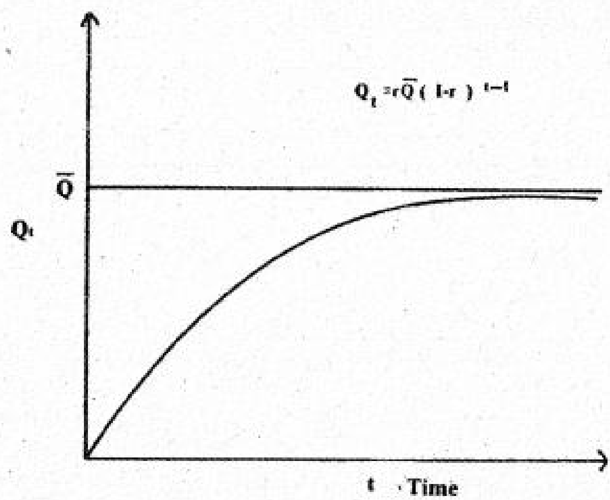

Fig. 9A.1: Diffusion Function.

The formula is completely specified by two parameters, r and $\bar{Q}$. To illustrate how it works, assume that a new technology is about to be introduced. The analyst estimates that 40% of the market base will eventually acquire the new technology ($\bar{Q}$ = 0.4). Further, he believes that in each period the penetration rate would be 30% of the remaining new potential customers (r=0.3). Therefore, the increment in new customer penetration of this market in the first period (Q_1) will be:

$Q_1 = r\bar{Q}(1-r)^{1-1} = r\bar{Q} = 0.3(0.4) = 0.12.$

This indicates that only 12% of the market base would be penetrated in the first period.

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LOCK 4 TECHNOLOGY ENVIRONMENT

: managers, particularly the top managers or general managers, should be fully versant with the environment that has a bearing on the technological component heir organisations. They should have indepth understanding of the policies, grammes, schemes, instruments and mechanisms of the Government which ether constitute the technological environment within which their enterprises rate. They should be thoroughly aware of and have a clear understanding of the lities, fiscal incentives, subsidies and other kinds of support offered by the vernment for promotion or development of technology and technological research. ;ood manager, in fact, is an avid watcher of the environment. Specifically, in this text, it might be beneficial for a manager to ask, periodically, the following stions:

What are the ingredients of the technology policies of the Government? How do they effect my organisation?

What incentives, facilities and support mechanisms are offered by the Government which have a bearing on my enterprise?

How can I fully exploit the opportunities offered by the policies, programmes, and schemes of the Government so that I could derive maximum benefit out of them?

What regulations or constraints are provided in those policies and programmes and how do they affect my enterprise? How best I can meet those challenges?

What opportunities are offered by the bilateral or multilateral arrangements? How can I avail of those opportunities?

ock 4 **Technology Environment** addresses itself to all that constitutes hnology environment.

it 10 deals, in general, with the development of **Science and Technology in India**. iat policies in relation to S&T have been pursued and what have been the main ists are discussed. That the pursuit of S&T policies led to the emergence of a ly strong S&T infrastructure is examined. An account is also given of the enditure incurred over the years on R&D by the Government and the industry. : institutional framework set up for research has been described. The interface ween S&T and the national planning in India and the place accorded to S&T in Five Year Plans are discussed. The contribution of Indian industry in industrial earch and the role of foreign collaborations are examined. The major ievements of S&T in India have been mentioned. The unit concludes with a brief ussion about Technology Missions approach followed over the recent past and perspective plan for 2001 AD.

t 11 deals with the **Policies, Incentives** and **Support Mechanisms** of the vernment of India. The unit begins with a detailed description of the science and inology policies. Since technological growth at the macro and micro levels is ely interrelated, and often interwoven, policies other than purely in the field of nce and technology, viz. industrial policy, trade policy, education policy etc.have siderable influence on technology management of the enterprise. Hence, the ortant provisions of all such policies which impinge upon technology nagement have been discussed. The unit then describes the incentives offered and port mechanisms available for various aspects of technology, mainly lernisation, upgradation, absorption, R&D etc, both for the large and small-scale istrial sectors. Towards the end, science and technology policies of some inced countries are also briefly examined in order to provide a comparative pective.

Unit 12 has its focus on **national and international linkages** in the field of technology. It first begins with a brief description about national institutions. The spotlight then shifts to international agencies and international cooperation in this field. Trade agreements and protocols entered into by India in this respect are discussed. What has been done by industry associations and other agencies to fost technological cooperation has been examined. Finally, the need for understanding linkages and making use of those linkages has been highlighted.

UNIT 10 SCIENCE AND TECHNOLOGY IN INDIA

Objectives

After studying this unit you should be able to:

- understand the development of science and technology (S&T) infrastructure in India
- appreciate the role of planning in relation to S&T
- know the major S&T achievements and technology missions and status of industrial research and import of technology in India;
- know about the perspective plan for 2001 AD for science and technology.

Structure

10.1 INTRODUCTION

Science and technology have been integral of the Indian culture. It was India which gave the world the concept of zero in Mathematics, distillation and perfumery in Chemistry,yoga and ayurveda in health-care, to name a few of her great achievements. Aryabhata the astronomer'and mathematician, Dhanvantari the physician, and Nagarjuna the chemist, are among the great scholar-scientists of ancient India. The astronomical observatories at Jaipur and New Delhi and the Ashok Pillar (made of non-rusting iron alloys) in New Delhi are living testimonies to the high level of Indian science and technology. The dawn of the present century witnessed, as a part of Indian renaissance, the blossoming of scientific doyens like Srinivasa Rarnanujan, J.C. Bose, P.C. Roy, Meghnad Saha, C.V. Raman, S.N. Bose, K.S.. Krishnan, Birbal Sahni, S.S. Bhatnagar, P.C. Mahalanobis, and M. Visvesvaraya. The great strides made by these gifted scientists and engineers in fields as diverse as pure mathematics and hydroelectric power generation will make any country proud.

In this unit, we will briefly dismiss science and technology policies in India, technology infrastructure and major achievements in science and technology, etc.

10.2 POST-INDEPENDENCE POLICIES AND THRUSTS

With the advent of Indian independence, foundations were laid for the development of modern scientific and technological enterprise in the country. It not only received blessings of and whole-hearted support from the country's first Prime Minister, Pandit Jawahar Lal Nehru, but continues to enjoy direct patronage of the highest political authority in the country. Even today, the Ministry of Science and Technology and the Departments of Atomic Energy, Electronics, Ocean Development and Space are under the direct charge of the Prime Minister who also continues to be the President of the Council of Scientific & Industrial Research - an organisation maintaining a chain of national laboratories. The blending of Nehru's blessings and Homi J. Bhabha's vision resulted in the emergence of atomic research in the country, leading to the institution of the Department of Atomic Energy. Likewise, the seeds of Indian space programme sown in rhumba were germinated by the vision and concerted efforts of Vikram Sarabhai, maturing into establishment of the Space Commission.

Nehru's commitment to use science for the socio-economic development of the country culminated in the formulation of the Scientific Policy Resolution (SPR) in 1958, the aim of which was to foster, promote and sustain the cultivation of sciences and scientific research in the country, and to encourage individual initiative for dissemination of scientific knowledge as well as to recognise the work of research scientists as an important contribution to the strength of the nation. As Indian science advanced, need was felt for development of newer indigenous technologies as well as for efficient absorption and adaptation of imported technologies. Accordingly, the Technology Policy Statement was issued in 1983, which laid emphasis on the attainment of technological competence and self-reliance, innovations, and identification and filling of technological gaps. The Government also adopted a host of other policies in such areas as health, oceanography, computers, textiles, electronics, education, drugs, and more recently minerals, which have provided guidelines for planned development. You will find detailed particulars about S&T policies in the next unit.

Besides policy framework, a number of specialised institutional structures have been created to meet the newer challenges. These include the sectors of biotechnology, non-conventional sources of energy, ocean development, environment and electronics resulting in the establishment of a wide S&T base in the country.

Excellence in Indian Science, both at individual and institutional levels is being increasingly recognised by the international scientific community by way of conferring honours, invitation to the named Chairs in major universities and election to fellowships of major science academies of the world. Some recent honours include election of a few eminent scientists to the fellowships of the Royal Society (UK), US National Academy of Sciences, etc.

The Scientific Advisory Council to the Prime Minister completed two tenures of two years each in February 1990, The Government of India has also constituted the National Council on Science and Technology as the apex body under the Chairmanship of the Prime Minister,

All these multi-dimensional efforts during the last four decades have resulted in the generation of a sound S&T infrastructure in the country, both in terms of manpower and capabilities. With a chain of nearly 200 national laboratories and an equal number of R&D institutions in the central sector coupled with about 1000 R&D units in the industrial sector, the country has not only achieved great success in various fields of science and technology but has also come a long way where it has become feasible to adapt and adopt technologies with a view to becoming self-sufficient. In attaining the present level of S&T in the country, the significant contributions made through international cooperation and exchange of scientific thought has also to be recognised. India continues to be a member of many international organisations on science and technology.

With a view to familiarise you with how the activities and efforts in relation to development of science and technology are organised, we present the organisation chart in Appendix-1, The Council of Scientific & Industrial Research (CSIR), being the Govt. of India's representative on the. Association for Science Cooperation in Asia (ASCA) and Commonwealth Science Council (CSC), has prepared a status report on science and technology in India. What now follows is mostly based on this report'.For the integration of S&T in the national planning process, Science and Technology Advisory Committees (STACs) have been formed in 20 socio-economic Ministries/Departments. Projecting long-term S&T programmes and identification of latest appropriate technologies in the relevant sector are the main objectives of each STAC.

While India has achieved a certain degree of excellence and recognition in some of the scientific fields, a similar place of pride is yet to be achieved in the area of technology. While Government has initiated several programmes and activities for promotion of technology development and related activities, the corporate sector is yet to stand-up to match the governmental efforts. The Indian corporate sector has so far operated under protective and practically non-competitive environment and therefore has not been adequately responsive to the international technological developments. However, the corporate sector appears to have now started realising the need and importance of technology as one of the crucial elements in its corporate management.

10.3 R&D EXPENDITURE

The status of S&T is generally assessed in terms of financial outlay and expenditure. There has been steady increase in the total allocation (plan + non-plan) for S&T from Rs. 200 million in the First Plan to Rs. 37,160 million in the Sixth Plan and to Rs. 75,000 million in the Seventh Plan as per break-up given in Table 10.1.

Table 10.1: Progress of S&T Expenditure in the Five Year Plans

Plan		*S&T expenditure (Rs. millions)*		
		plan	*non-plan*	*total*
1st Plan	(1951-56)	140	60	200
2nd Plan	(1956-61)	330	340	670
3rd Plan	(1961-66)	710	730	1440
4th Plan	(1969-74)	1420	2,310	3,730
5th Plan	(1974-79)	6,930	6,880	13,810
6th Plan	(1980-85)	20,640	16,520	37,160
7th Plan*	(1985-90)	43,980	31,370	75,350*

*estimated
Source: DST, GOI, R&D Statistics 1986-87

The ratio of the R&D expenditure to the GNP, which was 0.62 in 1980-81 has risen to 1.0 mark in 1988-89. R&D expenditure, in terms of this ratio for India, continues to be very low in comparison to the figures for advanced countries, as can be seen from Table 10.2.

Table 10.2: R&D Expenditures

(Rs. in crores-conversion to Rupees at 1989 rate)

Country	*% GNP*	*R&D Expenditure*
USA (1987)	2.7	2,00,000
Japan (1985)	2.8	90,000
FRG (1986)	2.6	44,000
USSR (1985)	4.0	35,000
France (1986)	2.3	28,000
UK (1986)	2.4	22,000
India (1988)	1.0	3,000

The distribution of S&T funding amongst different scientific agencies for the Sixth and Seventh Plans may be seen in Table 10.3.

Table 10.3: S&T Allocation (plan+non-plan) for Scientific Agencies

Agency	*Percentage of allocation/expenditure*	
	6th Plan	*7th Plan*
DAE	15.9	13.7
CSIR	13.9	11.6
DSIR	–	0.3
Space	13.1	14.2
DST	14.7	11.0
Environment	1.7	5.2
DOD	2.6	2.0
DBT	–	1.7
ICAR	14.6	10.9
ICMR	2.1	2.9
DNES	1.8	1.7
Electronics	0.6	0.5

Source: DST. GOI. R&D Statistics 1986-87

R&D expenditures of some Departments/Ministries are given in Table 10.4.

Table 10.4: R&D Expenditure of Some Departments/Ministries (Rs. million)

Department/Ministry	*Expenditure*
Department of Electronics	4090.0 (1985-90)
Department of Telecommunications	409.3 (1986-87)
Department of Steel	50.0 (1985-90)
Department of Mines	382.4 (1985-90)
Department of Coal	1200.00 (1985-90)
Ministry of Petroleum	2544.0 (1986-87)
Department of Power	568.0 (1984-87)
Ministry of Industry	2052.0 (1984-87)
Ministry of Railways	250.0 (1985-90)
Ministry of Surface and Transport	181.7 (1985-90)
Ministry of Civil Aviation	86.9 (1985-90)
Ministry of Civil Supplies	15.0 (1985-90)
Ministry of Urban Development	30.0 (1985-90)

It may thus be seen that though the R&D expenditure is about 1.0% of GNP, the amount in absolute terms is rather small, compared to other countries, for really meaningful R&D. Further, the expenditure is thinly distributed over various sectors of the economy and hence it has not been possible to have substantial innovations and technology developments. The efforts have been more of incremental nature or in the form of basic research in R&D institutions.

In-house R&D units of the industrial sector are expected to undertake both applied research and experimental research for development. For the institutional sector, there could be a mix of basic research combined with both applied research and experimental development. For this reason out of about 7730 products/processes/

import substitutes/design prototypes developed, about three quarters were by the industrial sector. Research laboratories in the institutional sector are also expected to provide consultancy services to industry. About 80% of the total activity in this regard was undertaken by the institutional sector.

S&T PERSONNEL

In 1950, the total stock of S&T personnel was estimated to be 0.188 million. It had increased to 3.14 million in 1985 and 3.8 million in 1990. The number of personnel engaged in R&D and related activities was .268 million as on April 'I, 1988. Out of this, only 36.7% were engaged primarily in R&D activities, 30.6% were performing auxiliary activities, and 32.7% were providing non-technical, including administrative support. Thus, the number of personnel actively engaged is far less, hardly 0.3% of the total stock. The percentage of personnel employed in institutional sector was 69% while it was 31% in the industrial sector. You will find some more particulars on S&T in the next unit.

10.4 RESEARCH INFRASTRUCTURE

The research system, as a part of the development of science and technology infrastructure, received considerable attention. The R&D infrastructure could be grouped under two categories. The first one consisted of institutions which were created during the colonial period. Considerable R&D capabilities were developed in them and they had a number of scientists with international reputation. The second group was made up of institutions which had been created after independence and covered newer areas of science and technology which had emerged since the Second World War. Scientists and technologists in these areas had to be trained. The first category of institutions was concerned with such areas as health, agriculture and industrial research. The second category related to such areas as atomic and renewable energy, electronics, environment, .biotechnology and space.

It is asserted that there was considerable experimentation in building the R&D infrastructure which covered five major dimensions.

- The research system was given functional autonomy so as to enable the R&D institutions to undertake bold and imaginative programmes on the one hand and to cover a certain degree of risk to be able to take chances.
- While allowing functional autonomy to the institutions, provisions were made to ensure accountability, covering both the utilisation of resources and the fulfilment of the objectives of the scientific and technological programmes.
- There was provision to enable the institutions to evolve proper policies and machinery for recruitment of scientific and technical personnel, their career development, promotion and recognition of merit.
- Producer-user relationship varied. Some R&D institutions produced results before users had been identified, while others were themselves users of their own R&D output, i.e. research, development and production systems were all within the same organisation.
- The organisations also had varying arrangements with regard to importing technology. Those organisations which were built-up around established research groups and did not control the utilisation of results of research had no control over the importation of technology while those organisations which were built around newer areas of science and technology and had control over utilisation of results of research took decisions about policies as well as about technology to be imported.

There are now seven distinct categories of science organisations in the country. Each of these categories has its own procedures regarding project selection, planning, resource utilisation, recruitment and manpower development, and mechanism as well as policies about the technology to be imported.

Autonomous Research Councils: These include the Council of Scientific & Industrial Research, the Indian Council of Agricultural Research, the Indian Council of Medical Research and four Central Councils for Research in Ayurveda and Siddha; Unani Medicine; Homoeopathy and; Yoga and Naturopathy.

Special Commissions: These are headed by eminent scientists, and were created, to cover new and emerging areas of science and technology; atomic energy; oil and natural gas; electronics; space; and additional sources of energy; besides Khadi and Village Industries Commission.

Institutions under Ministries: The old pattern of ministries having institutions under them to carry out research in specific areas was continued, e.g. in defence, health, education, industry and railways, etc. Their scope was, however, enlarged in the context of new demands and requirements, and greater resources were made available to them. New institutions added were the Departments of Science & Technology, Scientific & Industrial Research, Energy, Environment, and Ocean Development. These were established b coordinate research spread over different agencies and departments, and to take new initiatives when necessary.

Industrial R&D Establishments: Industry was encouraged to establish captive research institutions to meet the day-to-day requirements of production and technological improvements in both the public and private sectors. Government gave tax concessions to industry for investing in research. A number of industries, both in the public and private sectors, have taken advantage of incentives provided by the Government to establish R&D centres within the industry. One interesting feature of these developments is the advantage taken by R&D units established by the multinational corporations. A directory of selected research establishments in India is presented in Appendix-2.

Cooperative Research Associations: Government meets 50% of the expenditure where industry comes forward to establish cooperative research associations. So far such research associations have been established in industries such as textiles including man-made fibers, cement; rubber, paint, plywood, jute, tea, electrical, and automobiles. In some cases, government taxes the industry and receipts are used to fund the research for industry, e.g. cement.

Universities; The universities in India are mainly concerned with the advancement of knowledge rather than the development of marketable technologies. A number of centres for advanced research were established around distinguished scientists or around departments of established reputation. The Institutes of Technology (i.e. IITs) and Centres of Advanced Studies in Science and Technology have initiated from time to time some marketable research aimed at technological development.

Private Institutions: The government' provides incentives to people to invest in research by allowing tax exemption if the money is used for educational purposes or research. As a result of this policy, a large number of societies, foundations and trusts have been established. These organisations provide fellowships or grants for research or for establishing educational or research institutions with certain specific objectives.

The R&D infrastructure built up in a little over 40 years is remarkable in terms of size and capability. A list of selected S&T establishments, as mentioned earlier, is given at the end of this unit (Appendix 2) .The detail of the present S&T infrastructure and policies, in addition to the next unit, you will recall, were also discussed in some earlier units of this course.

Consultancy Organisations: Consultants play an important role in development and management of technology. The Government has been making conscious efforts to strengthen and promote consultancy services in India. Presently, there are over 1000 consultancy organisations in Public and Private sectors, including small consultants in various sectors such as civil engineering and construction management, educational consultancy, transportation, infrastructure development, railways, software development, telecommunications, chemicals & petroleum, power, metallurgy, & mechanical engineering with total annual turnover and exports of over Rs. 1000 crores and Rs. 250 crores respectively. Consultancy Development Centre set up by DSIR has the responsibility of catalysing such efforts. Consultants play an important role in acquisition and commercialisation of imported and indigenous technologies. NRDC (National Research Development Corporation) also acts as a linking agent between the suppliers and receivers of technologies.

Activity 1

i. Name five consultancy companies and your experience with them.

ii. Discuss the role played by consultants in technology management in your own organisation.

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10.5 S&T AND FIVE YEAR PLANS

India was perhaps the only country outside the socialist world which initiated a planned approach to the development of S&T through planning of scientific and technological research. In doing so, it evolved its own model of R&D planning. This approach can be seen from the policies evolved, as described earlier, and the thrust provided in different five year plans. The planning process adopted in India is a two-way process-giving broad policy guideline from above, and providing interaction with the scientists at national, agency and laboratory levels. While a plan is at the formulation stage, it is discussed with scientists at various levels, and is finalised after their reactions have been taken into account. The process is remarkable in so far as the number of scientists involved and the size of the country are considered. This democratization of decision-making and involvement of working scientists is supposed to ensure the latter's effective participation and to add to the vigor of science in the country.

The process essentially runs as follows:

- The government declares its policies, guidelines and thrusts, which are communicated to research agencies & institutions.
- Specialised panels covering different branches of science, areas of R&D and sectors of industry are set up to prepare plan documents for the respective areas.
- The heads of agencies and directors of laboratories are advised to prepare their plans, taking the guidelines and reports of the specialised panels into consideration.
- The directors, in turn, ask the working scientists, specialists in different branches of science, to prepare the plan of work.
- The plan of work prepared by different scientists and specialists is coordinated at the laboratory level, and discussed by the Scientific Advisory Panels of the respective laboratories, comprising scientists and technologists from universities, industries, other research institutions and officers from the concerned ministries.
- The laboratory level plans are coordinated at agency level and subjected to scrutiny by expert panels.
- The agency plans are coordinated and scrutinized at the Planning Commission level, finalised and resources allocated.

- The entire process takes about six months.

India has implemented seven five year plans so far. These plans gave significant place to S&T: We will briefly review the provisions relating to S&T in each of these plans.

The First Five Year Plan, launched in 1952, emphasised the establishment of scientific infrastructure. It provided funds for: the promotion of scientific and industrial research in already existing institutions; building of new laboratories; installation of necessary equipment to enable the laboratories to function; exploration and survey of resources; utilisation of byproducts and local resources; introduction of standardisation; and improvement of techniques in cottage industry. The most significant achievement during this period was the establishment of a chain of national laboratories and research institutes in essential disciplines, located in different parts of the country.

In the Second Plan, efforts were directed towards strengthening the existing research facilities by: coordination of the research programmes among various national agencies; linking up of research work at the national level with that at regional levels and state levels; training and generation of scientific manpower in sufficient numbers and their utilisation; and providing increasing opportunities to creative workers. It was during the Second Plan period that the Scientific Policy Resolution was adopted in 1958. The Resolution clearly spelt out the objective of according a prominent place and priority to science in the national plans.

Emphasis in the Third Plan was on encouraging basic research in universities, training of research personnel and expanding the programme of research fellowships and scholarships; development and manufacture of scientific and industrial instruments in pilot plant trials and full scale field experiments. During the Third Plan, scientific and technological research is started to have made perceptible contribution to the development of the country. The growth and development trends were evident from the improved farming methods employed, better health and speedier transport facilities evolved, fruitful use of land and water resources and a considerable increase in the generation of energy for industrial use. A large number of management problems had come up during the Third Plan and subsequently most of the problems remained untackled, as the visible return from R&D was not considered a criterion for investment. This attracted considerable public attention. The application and commercial exploitation of only small proportion of the scientific results achieved were looked into seriously with a view to identifying the causes.

Efforts in the Fourth Plan were directed towards integrating industrial research with programmes of industrial development; achievement of greater coordinatiod at inter-laboratory level; and evaluation of research programmes periodically at different levels.

There was a major departure during the preparation of the Fifth Plan, in terms of the formulation machinery made use of. First, a document entitled "Approach to Fifth Five Year Plan" was prepared and circulated widely *for* comments. Further, a series of meetings were organised in different parts of the country to discuss the document. In the light of the comments received and discussions held, the document was finalised and expert panels for different areas of S&T were formed. The panels submitted their plans taking the document into account. These plans were then integrated at the level of the Planning Commission.

In the formulation of the Sixth Plan, a different procedure was followed. The draft plan was prepared by the Vice-President of the CSIR, who was entrusted with this responsibility by the Prime Minister. For this, the Vice-President had wide-ranging discussions with scientists all *over* the country. The draft document was circulated widely and discussed in a conference of over three hundred eminent scientists and technologists from different areas. The document was finalised by a panel of experts formed by the Department of Science & Technology. It was then discussed by the Planning Commission and a modified document was included in the Sixth Five Year Plan. The S&T plan, which is integrated with the national plan, was formulated with the objectives which would subserve those of the national plan during the period. The Technology Policy Statement (TPS) was announced in January .1983. This was a major policy statement by the Government covering a whole range of issues relating to technology: indigenous development, assessment, forecasting, imports and subsequent absorption, adaptation and further development, fiscal aspects, etc. While the main thrust of the Fifth Five Year Plan was removal of poverty and attainment of self-reliance, the thrust of the Sixth Five Year Plan was on growth, modernisation, self-reliance and social justice.

The guiding principles of the Seventh Five Year Plan continued to be growth, equity and social justice, self-reliance, improved efficiency and productivity. In addition, emphasis was laid on growth, in food production and increased employment opportunities. A mission-oriented approach adapted to technological development was started with a view to focusing S&T efforts and fostering relevance, providing motivation and establishing organic linkages between various sectors concerned with implementation and introducing a sense of urgency to delivery of the task in a time targeted manner. The process of liberalisation of the economy initiated in 1980 accelerated during this period. The impact of technology was allowed on a selective basis for upgrading and modernisation of existing technology as well as including indigenous R&D to compete internationally.

After the 7th plan was over, only the annual plans were formulated and implemented for the years 1990-91 and 1991-92'3'he Eighth Five Year Plan is stated to begin from 1st April, 1992 and is to focus on development of S&T in areas of strategic importance such as space, energy, defence, transport, comtnunications, and applications of S&T for the benefit of masses, including population control, rural development, employment expansion, increasing exports, and so on.

It has been felt that the successive Five Year Plans have predominantly emphasised the development of science. Technology is yet to receive adequate attention in the planning process.

10.6 INDIAN 1NDUTRY AND INDUSTRIAL RESEARCH

Recognising that R&D and technology are the watchwords for maintaining an edge with respect to quality and cost in today's competitive world, Government has taken several measures towards promoting (industrial) research in industry itself and to establish workable linkages between industry, the national laboratories and educational institutions. Several incentives have also been provided which encourage and make it financially attractive for private, joint and public sector industrial units to establish their own in-house R&D centres. The technology policy statement (1983) of the Government of India also referred to the in-house R&D units and stated that "In-house R&D units in industry provide a desirable and essential interface between efforts within the national laboratories and the educational sector as well as production in industry. Appropriate incentives will be given to the setting up of R&D units in industry and for industry including those in cooperative sector. Enterprises will be encouraged to set up R&D units of a size to permit the accomplishment of major technological tasks."

At present there are nearly 1200 in-house R&D units having valid recognition from the Departments of Scientific & Industrial Research. A sector-wise break up of these industrial R&D units is given in Table 10.5.

Table 10.5: Sector-wise Break up of R&D Centres

Chemical & Allied Industries		350
Electrical & Electronics Industries		250
Mechanical Industries		225
Processing Industries		300
Agro Industries and others		75
	Total	1200

These R&D units employ over 65000 S&T personnel. This include over 2500 doctorate degree holders. These units have also acquired infrastructural facilities such as sophisticated instruments, testing instruments, pilot plant facilities, design and prototype development facilities, etc., costing around Rs 800 crores. They are also spending nearly Rs. 800 crores every year towards their R&D activities [5]. This expenditure has behind it only about half of the industrial production in the country and is approximately 0.7% of sales turnover. The other half of the industrial production is not at all influenced by any R&D within the industry. In the small scale sector, it is still worse. R&D expenditure incurred by small scale sector in over 250 units recognised by DSIR is hardly Rs. 20 crores, i.e. less than 0.1% of the turnover attributed to small scale sector.

The incentives and support measures presently available to the recognised R&D units includei import facilities under OGL, income tax relief, accelerated depreciation allowances, exemption from price control order for bulk drugs, international R&D collaborations approval/arrangements, national awards, and other indirect benefits.

Activity 2

Does your company have a recognised R&D centre/unit? What is its status? Indicate its usefulness (or contribution) for (to the) technology management in your company.

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10.7 FOREIGN COLLABORATIONS

One of the routes of acquiring technology and technical support at enterprise level is through import of capital goods, and imports arising from foreign collaboration arrangements. The Government has allowed such arrangements on selective basis, and according to a set of criteria stipulated under terms and conditions involving payments, utilisation of indigenous resources, etc. These conditions have however been considerably liberalised recently. It is 'estimated that a substantial part of total industrial production is based on imported technologies in India.

In DSIR's recently brought out compilation of data relating to foreign collaborations (FCs) approved by the Government during 1981-89[6], it has been revealed that there have been over 13000 collaborations over the years in India, the maximum number (1041) being in 1985. There were 639 FCs approved during 1989. Details of collaborations approved during 1976-1986 are given in Table 10.6. It will be observed that Electricals & Electronics have accounted for about 25% of the total FCs, followed by Industrial Machinery and Mechanical Engineering sectors. The study further indicated that USA accounted for about 21% of the total FCs and has thus been the largest partner of India in this respect, followed by FRG (18%), UK (12%), Japan (10%), Italy (6%), France (4%), Switzerland (4%), Sweden (3%). Total foreign investment during the year 1989 has been Rs. 288 crores, out of which US contributed maximum (Rs. 55 crores), followed by UK (Rs. 33 crores). A total of Rs.

700 crores (gross of taxes) was approved as lump sum technology payments during the year 1989 as against Rs. 584 crores and Rs. 418 crores during 1988 and 1987 respectively. Thus, although the number of FCs were more in 1988 and 1989, the technology payments were lesser. The chemical sector accounted for 37% of technology payments during 1981-89,,followed by electrical & electronics (16%), industrial machinery (11%), metallurgical (12%) and mechanical engineering sector (7%). A total of 17 extensions to FCs were granted during the year 1989 and 94 cases carried export obligations.

Table 10.6: Foreign Collaboration Approvals 1976-1989

Year	Sectors											
	1	2	3	4	5	6	7	8	9	10	11	Total
1976	–	32	63	57	13	19	12	2	19	–	60	277
1977	–	23	67	74	4	10	7	2	19	–	61	267
1978	–	30	48	76	7	20	18	2	22	–	84	307
1979	–	24	52	72	15	14	12	–	26	–	52	267
1980	–	52	114	121	29	26	31	6	41	–	106	526
1981	–	27	55	96	49	5	9	5	19	–	42	389
1982	3	54	134	110	125	6	36	7	24	7	82	588
1983	5	76	149	144	69	24	24	3	34	11	134	673
1984	4	85	162	169	99	27	32	7	25	10	120	740
1985	14	69	315	215	89	38	54	13	52	20	162	1041
1986	5	135	246	87	145	28	69	16	54	–	175	960
1987	4	138	227	165	83	24	35	11	39	9	168	903
1988	3	136	243	170	92	24	55	25	40	18	151	957
1989	2	80	111	74	75	11	35	11	18	25	197	639

Source: DSIR, March 1991, Handbook of Foreign Collaborations Approved during 1981-89, p. xxii

Legend: 1.–Alternative/renewable energy 2–Chemicals Electronics 4–Industrial machinery 5–Mechanical Engg. 6–Machine tools 7–Metallurgy 8–Textiles 9–Transport 10–Consultancy & Energy sources 11–Misc. and R&D.

10.8 MAJOR S&T ACHIEVEMENTS

The developments in S&T since independence have been many and varied in nature. They have aimed at developing indigenous capabilities, meeting the demands of industry, and providing opportunities to people to realise their creativity and contribute to the efforts to create a better India. S&T contributions cover wide ranging areas, such as research publications, patents, process know-how developments, giving expert advice, providing consultancy and turnkey jobs for industry. India has made some notable strides in import substitution and has also been exporting technologies and services to other countries. Many of the Indian enterprises have set up joint ventures abroad which is indicative of Indian S&T capabilities.

The achievements in industrial research cover areas, such as chemicals and chemical engineering, drugs and pharmaceuticals, food and beverages, polymers, pesticides, paper and pulp, leather and leather accessories, buildings and building materials, electronics, metals and alloys, machinery and equipment, glass ceramics and refractories, medical research, ocean research, space research, satellites, aeronautical research, atomic energy, agriculture, coal, energy sources, etc. The Indian S&T capabilities have been amply demonstrated through launching of indigenously built satellites, construction of atomic power houses and other peaceful uses of atomic energy, development, manufacture and installation of telecommunication systems, self-sufficiency in agriculture, and so on.

The corporate sector has also developed and commercialised a number of products and processes through their in-house R&D efforts in various areas, such as electrical equipment, drugs and pharmaceuticals, chemicals, instrumentation, and so on which have resulted in savings of foreign exchange through import substitution or the products meeting the domestic requirements or exports. However, the corporate efforts need to be stepped up to realise the full potential available in terms of infrastructure and capabilities.

Some of the achievements in the industrial sector include development and production of Swaraj Tractors by M/s Punjab Tractors Ltd., Chandigarh; and Amul Baby Food by Indian Dairy Development Board in Gujarat. There have been several examples of R&D achievements in the industrial sector from time to time. For example, in-house R&D unit of M/s Polychem Limited in Bombay has developed an indigenous process for Divinylbenzene Monomer (DVB) and successfully commercialised it fully meeting the standards of quality. The manufacturing process for DVB is complex and its development is centered around the design of multi-tower, high vacuum, high efficiency, low pressure drop distillation systems, selection of catalyst and optimization of process parameters overcoming the problems of catalyst fouling and incorporation of energy saving systems like waste heat boilers, condensate recovery and lowest possible reflux ratios, thereby reducing manufacturing cost. DVB is an import substitution product and foreign exchange savings of over Rs. 250 lakhs per year have been affected. This company is the only DVB producer in Asia excluding Japan.

As mentioned earlier, in general, however most of the developmental efforts have been towards import substitution and incremental developments in the form of upgradation of products, cost reduction, etc: Production of commercial vehicles, passenger cars, two-wheelers in the transport sector, textiles, steel, fertilizers, papers, colour televisions and some electronic components, consumer items etc. are produced today mostly based on imported technologies but adapted to Indian conditions. These technologies have been more or less indigenised fully.

10.9 TECHNOLOGY MISSIONS

The national technology missions are package programmes meant to speed up economic and social development in India and were initiated during the Seventh Plan period in 1985. Focusing on some key human needs, they break-up the processes of change and delivery into manageable tasks. These missions are on: drinking water, immunisation, literacy, oilseeds, dairy development, telecommunications, and social forestry, and are aimed to:

- significantly improve the availability and quality of drinking water in rural areas;
- immunise all infants against six grievous diseases and pregnant women against tetanus;
- make a substantial proportion of the population functionally literate;
- cut down imports of edible oils;
- improve milk production and rural employment;
- extend, improve and innovate telecommunications; and
- cover 17 million hactare of land under social forestry by 1995.

The missions aim to place technology in the hands of the people and at their service. They emphasise work in the laboratory as well as swift transfer of the results to villages and fields.

The special purpose of the missions is to fill in people the zeal required to make things happen quickly and to help the changes endure. A great deal of mission implementation takes place through the states. Coordination among central, state, and district level administrations as well as coordination with voluntary agencies, the non-governmental sector, the private sector and international agencies, is an important part of mission direction at the centre. The Technology Missions were coordinated by an Adviser in the Prime Minister's Office until late 1989.

10.10 PERSPECTIVE PLAN FOR 2001 AD

The Science Advisory Council to the Prime Minister was constituted in 1986 under the Chairmanship of Prof. C.N.R. Rao, as an apex body to advise the Prime Minister on major issues relating to science and technology in the country, and also to prepare a perspective science and technology plan for 2001 AD. The Council submitted its paper "An Approach to a Perspective Plan for 2001 AD-Role of Science and Technology" in July 1988. The plan emphasised the need to incorporate science and technology in planning for development. The recommendations of the Council have been printed in the form of two volumes. It has been emphasised that the role of S&T needs to be examined in two parts:

a) use of S&T in planning; and
b) planning for S&T.

Some of the important issues considered included the following:

- control of population;
- need for increased food production;
- protection of the environment;
- improving human health;
- control of hyper urbanisation; and
- reducing unemployment.

The other crucial sectors identified were energy, communications, transport, manufacturing, materials, instrumentation and higher education.

The Council has further identified critical issues and areas for development and an action plan has been recommended. The identified frontier areas of research and development include advanced materials, photonics, genetic research, lasers, parallel computing, instrumentation, robotics and manufacturing automation. The socio-economic areas of relevance include the management of renewable resources, health care, fertilizer use, future food needs, chemical industry, water transport, minerals development and building materials.

Activity 3

Study "The Approach to Perspective Plan for 2001 AD for S&T." Does it adequately cover the technology requirements at enterprise level? Comment. Suggest at least two points that you would like them to be considered for inclusion in the perspective plan to make it more effective.

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Activity 4

Prepare a Technology Plan for your company/organisation for the next 10 years.

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10.11 SUMMARY

India has consciously followed the path of planned development for science and technology, and has developed a strong S&T base in terms of infrastructure and policies. There have been significant S&T achievements in various areas, such as, atomic *energy,* space, agriculture, telecommunications, computer software, chemicals and pharmaceuticals, industrial machinery, etc. Nearly 1200 in-house R&D units in enterprises/companies with reasonable R&D infrastructure have been recognised. These developments have however been mostly science based and technological aspects are yet to receive adequate attention from the Government as well as the corporate sector. Technology import has been an important mode of transfer of technology to Indian enterprises, and more than 13000 foreign collaborations (FCs) have been approved by the Government over the years, involving technology payments. USA has been a major technology supplier as well as investor in India, as per the data available relating to FCs. These FCs have been mainly in electrical & electronics, industrial machinery, mechanical & metallurgical industries. Indian companies have adopted the imported technology to produce items locally but further efforts to absorb and adapt such technologies are needed.

10.12 KEY WORDS

CSIR: Council of Scientific and Industrial Research is an autonomous body set up by the Government of India, with the Prime Minister as its President, to promote and develop scientific and industrial research in India.

Infrastructure: Framework, facilities and mechanisms for development, promotion and utilisation of S&T capabilities or know-why.

Technology Missions: Package programmes meant to speed up economic and social development in India.

Science Advisory Council to the Prime Minister: A group of experts/scientists appointed by the Prime Minister to advise him on matters related to S&T.

Plan for 2001 AD: A report prepared by the Advisory Council to the Prime Minister that identifies the S&T perspectives, goals and approaches to achieve objectives for national development by the year 2001 AD.

In-house R&D: Industrial research in industry, mainly by the industry, with encouragement and support provided by the Government.

Foreign Collaborations: A collaborative arrangement on mutually agreed terms for acquiring technology from abroad.

10.13 SELF-ASSESSMENT QUESTIONS

1) What is the organisational structure for S&T development in India? Discuss.
2) It is stated that, over the years, too many departments and organisations have come up for S&T in India, and there is overlapping in their functions and programmes. Do you agree? Discuss.
3) The S&T investments in India in relation to output have not been adequate. Comment and compare with S&T expenditures in some other well-known countries.
4) Name some of the cooperative R&D centres in different sectors of industry. Do you think that Cooperative Research Centres are more efficient or useful than fully public funded research institutions? Comment.
5) Discuss the role of a cooperative research organisation in technology development and management that you might be aware of.
6) Briefly discuss the development of S&T in India and comment.
7) Briefly discuss the planning process for S&T in successive five year plans in India and the emphasis given in each plan.
8) Discuss the role the national S&T infrastructure can play in technology management and technology development at the corporate level. Examine

the linkage with examples/illustrations.

9) Write a short note on import of technology through foreign collaboration arrangements in India.
10) What was the objective of Technology Missions? Indicate the areas of various Technology Missions.
11) Is the Technology Missions approach useful? Does it need to be pursued more vigorously in future? Give reasons in support of your answer.
12) Discuss the role of S&T in future, say by 2001 AD?

10.14 FURTHER READINGS

Babu V. Vithal; Aug. 1991, *Trade and Technology Directory in India*, Volumes I & II, Economy & Trade, New Delhi

CSIR, 1990, *Status Report on Science & Technology in India*, New Delhi.

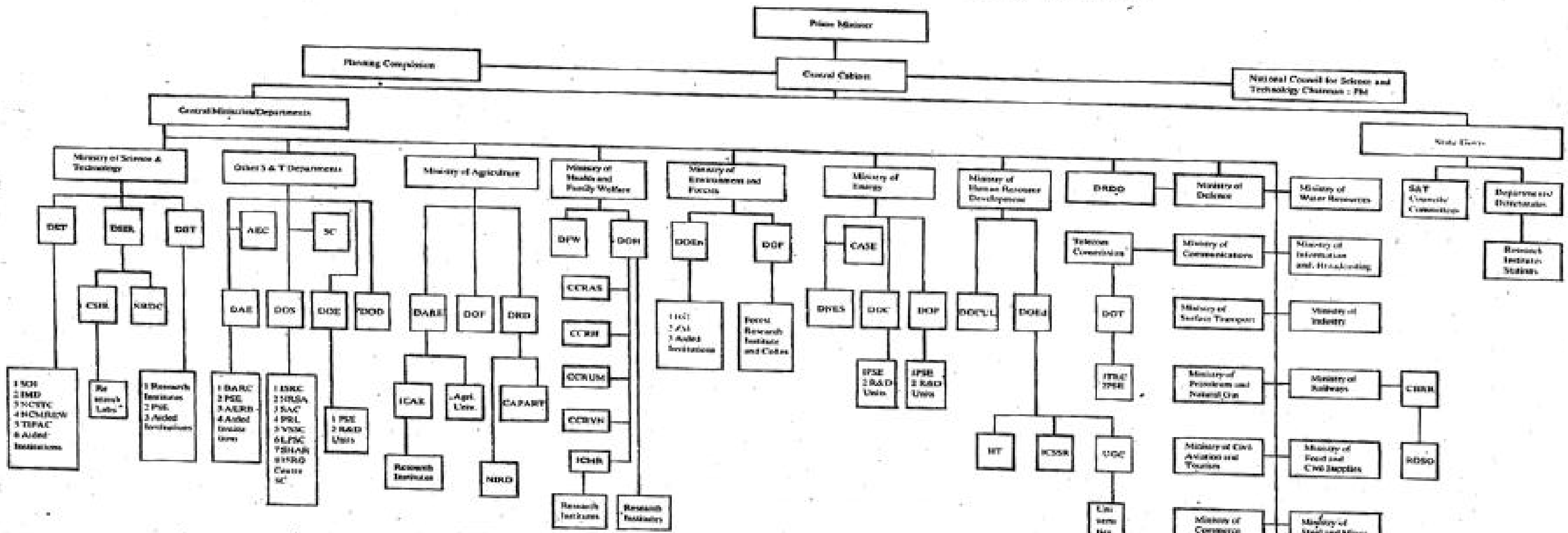
Rahman A., (Ed.) 1984. *Science and Technology-Indian Culture,* NISTADS, New Delhi, 1984.

References

1) Council of Scientific & Industrial Research, New Delhi, *Status Report on Science and Technology in India: 1990.*
2) Ibid.
3) Ibid.
4) Rahman A. (Ed.), *Science and Technology in India,* Pakistan, Bangladesh & Sri Lanka, Longman, 1990.
5) DSIR, Dec., 1991, *R&D in Industry-An Overview.*
6) DSIR, March, 1991, *Handbook of Foreign Collaborations* Approved during 1981-89.
7) *Perspectives in Science and Technology (Vol. I & II),* 1990 Science Advisory Council to the Prime Minister, Deptt. of Science and Technology, New Delhi.

Appendix 1

Organizational Chart of Science and Technology in India



AEC	Atomic Energy Commission
AERB	Atomic Energy Regulatory Board
BARC	Bhabha Atomic Research Centre
BSI	Botanical Survey of India
CAPART	Council for Advancement of People's Action and Rural Technology
CASE	Commission on Additional Sources of Energy
CBRR	Central Board of Railway Research
CCRAS	Central Council for Research in Ayurveda and Siddha
CCRH	Central Council for Research in Homoeopathy
CCRUM	Central Council for Research in Unani Medicine
CCRYN	Central Council for Research in Yoga and Naturopathy
CSIR	Council of Scientific and Industrial Research
DAE	Department of Atomic Energy
DARE	Department of Agricultural Research and Education
DBT	Department of Biotechnology
DFW	Department of Family Welfare
DNES	Department of Non-Conventional Energy Sources
DOC	Department of Coal
DOCUL	Department of Culture
DOD	Department of Ocean Development
DOE	Department of Electronics
DOEd	Department of Education
DOEn	Department of Environment
DOF	Department of Fertilizers
DOF	Department of Forest
DOH	Department of Health
DOP	Department of Power
DOS	Department of Space
DOT	Department of Telecommunications
DRDO	Defence Research and Development Organisation
DSIR	Department of Science and Technology
ICAR	Indian Council of Agricultural Research
ICMR	Indian Council of Medical Research
ICSSR	Indian Council of Social Scientific Research
IIT	Indian Institute of Technology
IMD	Indian Meteorological Department
ISRO	Indian Space Research Organisation
ISROSC	ISRO Satellite Centre
LPSC	Liquid Propulsion Systems Centre
NCMRWF	National Centre for Medium Range Weather Forecasting
NIRD	National Institute of Rural Development
NRDC	National Research in Development Corporation
NRSA	National Remote Sensing Agency
PRL	Physical Research Laboratory
PSE	Public Sector Enterprises
RDSO	Research Design and Standards Organisation
SAC	Space Applications Centre
SC	Space Commission
SOI	Survey of India
TIFAC	Technology Information Forecasting and Assessment Council
TRC	Telecommunication Research Centre
UGC	University Grants Commission
VSSC	Vikram Sarabhai Space Centre
ZSI	Zoological Survey of India

Appendix 2: Directory of selected research establishments in India Aeronautical

Development Establishment. *Address:* Bangalore

Agricultural Tools Research Centre. *Address:* Suruchi Campus, Post Box 4, Bardoli 394601, Gujarat.

Agro-Economic Research Centre. *Address:* PO District Birbhum State, Santiniketan 731235, West Bengal

Alipore Observatory and Meteorological Office. *Address:* Calcutta

All India Coordinated Research Project on Dryland Agriculture. *Address:* Santosh Nagar, PO Saidabad, Hyderabad 500659, Andhra Pradesh

All India Institute of Medical Sciences. *Address:* Ansari Nagar, New Delhi 110029

Atomic Energy Establishment.. *Address:* Bombay

Automative Research Association of India. *Address: Post* Box *832,* Puna 411004, Maharashtra

B.M. Institute of Mental Health. *Address:* Ashram Road, Navrangpura, Ahmedabad, Gujarat

Bhabha Atomic Research Centre. *Address:* Chhatrapati Shivaji Marg, Bombay 400085

Bharat Electronics Limited. *Address:* 29/4 Race Course Road, Bangalore 560001

Bharat Heavy Electricals Limited. *Address:* 18-20 Kasturba Gandhi Marg, New Delhi 110001

Birla Institute of Technology and Science. *Address:* Pilani 333031, Rajasthan

Bureau of Indian Standards. *Address: 9* Bahadur Shah Zafar Marg, New Delhi

Cancer Research Institute. *Address:* Dr Ernest Borges Marg, Parepombay 400012, Maharashtra

Central Agricultural Research Institute for Andaman'and Nicobar Islands. *Address:* Port Blair 744101, Andaman and Nicobar Islands

Central Arid Zone Research Centre, Jodhpur. *Address:* Light Industrial Area, Jodhpur 342003 Rajasthan

Central Avian Research Institute. *Address:* Izatnagar, Uttar Pradesh

Central Building Research Institute. *Address:* Roorkee 247667, Uttar Pradesh

Central Capture Fisheries Research Institute. *Address:* Barrackpore PO, 24 Parganas, 731101, West Bengal

Central Crops Research Institute. *Address:* Post Kudlu, Kasaragod 670124, Cannannore District, Kerala

Central Drug Research Institute. *Address:* Post Box 173, Lucknow 226001, Uttar Pradesh

Central Electrochemical Research Institute. *Address:* CECRI Nagar, Karaikudi 623006

Central Food Technological Research Institute *Address:* Food Technology Post Office, Mysore 570013

Central Fuel Research Institute. *Address:* PO FRI, Dhanbad 828108

Central Glass and Ceramics Research Institute. *Address:* PO Jadavpur University, Calcutta 700032

Central Institute for Cotton Research. *Address: 95* Pushp Kunj, Canal Road, New Rardaspeth, Nagpur 440001

Central Institute for Research on Buffaloes. *Address:* Sirsa Road, Hisar, Haryana

Central Institute for Research on Goats, *Address:* Makhdoom P() Farah, District Mathura 281122, Uttar Pradesh

Central Institute of Agricultural Engineering. *Address:* Shri Guru Tegh

BahadurComplex, T.T. Nagar, Bhopal 462003, Madhya Pradesh

Central Institute of Fisheries Education. *Address:* Post Box 7392, Jaiprakash Road, Andheri (West), Bombay 400058

Central Institute of Fisheries Technology. *Address:* Willingdon Island, Matsyapuri PO, 682029, Cochin

Central Institute of Horticulture for Northern Plains. *Address:* B-217, Indira Nagar, Lucknow 226016

Central Institute of Medicinal and Aromatic Plants. *Address:* Post Bag 1, PO.Ram Sagar Misra Nagar, Lucknow 226016

Central Jalna Institute for Leprosy. *Address:* Post Box 31, Tak Ganj, Agra 282001, Uttar Pradesh

Central Leather Research Institute. *Address:* Adyar, Madras 600020

Central Machine Tools Institute. *Address:* Tumkur Road, Bangalore 560022, Karnataka

Central Marine Fisheries Research Institute. *Address:* Post Box 2704, Cochin 682031, Kerala

Central Mechanical Engineering Research Institute. *Address:* Mahatma Gandhi Avenue, Durgapur 713209, West Bengal

Central Mining Research Station. *Address:* Barwa Road, Dhanbad 826001

Central Potato Research Institute. *Address:* Post Box, Simla 171001, Himachal Pradesh

Central Research Institute. *Address:* Kasauli, Himachal Pradesh

Central Rice Research Institute. *Address:* Cuttack, Orissa 753006

Central Road Research InstituteAddress: PO CRRI, Delhi-Mathura Marg, Bhavnagar, Gujarat

Central Scientific Instruments Organizations. *Address:* Sector 30, Chandigarh 160020

Central Sheep and Wool Research Institute. *Address:* Post Office, Avikanagar 302451, Jaipur, Rajasthan

Central Soil and Water Conservation Research and Training Institute. *Address:* 218 Kaulagarh Road, Dehradun 248195, Uttar Pradesh

Central Tobacco Research Lastitute. *Address:* Rajahmundry 533105, Andhra Pradesh

Central Water and Power Research Station. *Address:* Khadakwasla Research Station, Pune 411024

Commission of Non-Conventional Energy Sources. *Address:* New Delhi 110001

Council for Advancement of People's Action and Rural Technology. *Address:* *Address:* New Delhi.

Council for Scientific and Industrial Research. *Address:* Rafi Marg, New Delhi 110001

Defence Research and Development Organization. *Address:* South Block, New Delhi 110011

Department of Atomic Energy. *Address:* Chhatrapati Shivaji Maharaj Marg, Hyderabad 500016, Andhra Pradesh

Department of Ocean Development. *Address:* New Delhi

Department of Science and Technology. *Address:* Technology Bhavan, New Mehrauli Road, New Delhi 110016

Development Consultants Private Limited. *Address:* 24B Park Street, Calcutta

700016, West Bengal

Gas Turbine Research Establishment. *Address:* Suranjan Das Road, Bangalore 560075

Gujarat Communications and Electronics Limited. *Address:"Express* Building, RC Dutt Road, Baroda 390005

Hindustan Aeronautics Limited. *Address:* Post Bag 1789, Bangalore 560017

Hindustan Cables Limited. *Address:* Hyderabad Unit, PO Hindustan Cables, Hyderabad 500005

Hindustan Ciba-Geigy Limited Research Centre. *Address:* Aarcy Road, Goregaon East, Bombay 400063

Hindustan Lever Research Centre. *Address:* ICT Link Road, Andhcri East, Bombay 400099, Maharashtra

HMT Limited, Research and Development Centre. *Address:* Tumkur Road, angalore 560022, Karnataka

Indian Agricultural Research Institute. *Address:* New Delhi 110012

Indian Agricultural Statistics Research Institute. *Address:* Library Avenue, Pusa, New Delhi 110012

Indian Council of Agricultural **Research.** *Address:* Krishi Bhavan, Dr. Rajendra Prasad Road, New Delhi 110001

Indian Institute of Chemical Biology. *Address: 4* Raja S.C. Mullick Road, Jadavpur, Calcutta 700032

Indian Institute of Science. *Address:* Bangalore 560012, Karnataka

Indian Institute of Technology. *Address:* PO Kharagpur 11, 721302, West Bengal
Indian Institute of Technology, Bombay. *Address:* Powai, Bombay 400076

Indian Institute of Tropical Meteorology. *Address:* Ramburg House, University Road, Puna 411005

Indian Meteorological Department. *Address:* Lodi Road, New Delhi 110003

Indian National Science Academy. *Address,* Bahadur Shah Zafar Marg, New Delhi 110002

Indian Space Research Organization. *Address:* Cauvery Bhavan,District Office Road, Bangalore 560009

Indian Telephone Industries Limited. *Address:* 16 Museum Road, Bangalore 560001

Indian Veterinary Research Institute, *Address:* PO Izatnagar 243122, Uttar Pradesh

Indira Gandhi Centre for Atomic Research. *Address:* Chhatrapati Shivaji Maharaj Marg, Bombay 400039

Industrial Toxicology Research Centre. *Address:* Post Box 80, M.G. Marg.

Institute *for* Research in Medical Statistics. *Address:* 1 Sathyamuthhi Road, Madras 600031, *Tamil* Nadu

Institute for Research in Reproduction. *Address:* Jehangir Mebwanji Street, Parel, Bombay 400012, Maharashtra

Institute of Hydraulics and Hydrology. *Address:* Poondi 602023, Trivellore, Tamil Nadu

Institute of Immunohaemafology. *Address:* Parel, Bombay 400012, Maharashtra

Institute of Mathematical Sciences. *Address:* T.T.T.I. Tharamani PO, Madras 600113, Tamil *Nadu*

Institute of Microbial Technology. *Address:* 1389 •Sector 33C, Chandigarh 160031

International Crop Research Institute for the Semi-arid Tropics. *Address:* Hyderabad

ISRO Satellite Station. *Address:* A1-6 Peenya Industrial Estate, Bangalore, Karnataka

Jute Agricultural Research Institute. *Address:* 24 Paraganas, PO Barrackpore 743101, West Bengal

Khadi and Village Industries Commission. *Address:* Bombay

Laboratory Animals Information Service Centre. *Address: BP 4508,* New Delhi 110029

Maharashtra Association for the Cultivation of Science. *Address:* Law College Road, Pune 411004

Malaria Research Centre. *Address: 25* Sham Nath Marg, Delhi 110054

National Aeronautical Laboratory. *Address:* Post Box 1779, Kodihalli, Bangalore 560017, Karnataka

National Botanical Research Institute. *Address:* Rana Pratap Marg, Lucknow 226001

National Dairy Research Institute. *Address:* Karnal 132001, Haryana

National Environmental Engineering Research Centre. *Address:* Nehru Marg, Nagpur 440020

National Geophysical Research Institute. *Address:* Uppal Road, Hyderabad *500007*

National Informatics Centre. *Address:* Pushpa Bhawan. E Wing, Madangir Road, New Delhi, 110062

National Institute of Cholera and Enteric Diseases. *Address:* P-33 CIT Scheme ACM, Belighata, Calcutta 700010, West Bengal

National Institute of Communicable Diseases. *Address: 22* Sham Nath Marg, Delhi 110054

National Institute of Health and Family Welfare. *Address:* New Mehrauli Road, Munirka, New Delhi 110067

National Institute of Mental Health and Neurosciences. *Address:* Post Box *2979,* Bangalore, Karnataka

National Institute of Nutrition. *Address:* Jamia-Osmania, Hyderabad 500007, Andhra Pradesh

National Institute of Oceanography. *Address:* Dona Paul, Goa 403004

National Institute of Occupational Health. *Address:* Meghani Nagar, Ahmedabad 380016, Gujarat

National Institute of Science, Technology Development Studies. *Address:* Hillside Road, New Delhi 110012

National Institute of Virology. *Address:* Post Box 11, *20A* Dr Ambedkar Road, Pune 411001, Maharashtra

National Metallurgical Laboratory. *Address;* PO Burnamines, Jamshedpur 831007

National Physical Laboratory. *Address:* Hillside Road, New Delhi 110012

National Remote Sensing Agency. *Address:* Balangar, Hyderabad 500037, Andhra Pradesh

National Tuberculosis Institute. *Address:* 8 Bellary Road, Bangalore *560003,* Karnakata

Pasteur Institute of India. *Address:* Coonor 643103, Nilgiris

Physical Research Laboratory. *Address:* Navrangpura, Ahmedabad 380009, Gujarat

Punjab Communications Limited. *Address: 32,* Phase 11, Industrial Focal Point, Nagar 160051, Punjab

Punjab and Development India Limited. *Address:* PO Sindri, Dhanbad 828122, Bihar Technology Environment

Rajendra Memorial Research Institute of Medical Sciences. *Address:* Agam Kuan, Patna 800007, Bihar

Reactor Research Centre. *Address:* Chingleput District, Kalpakkam 603102, Tamil

Nadu

Regional Research Laboratory. *Address:* Library Building (Ground Floor), University of Bhopal, Bhopal 462026

Regional Research Laboratory. *Address:* Bhubaneswar 751013

Regional Research Laboratory. Address:.Uppal Road, Hyderabad 500007

Regional Research Laboratory. *Address:* Canal Road, Jammu Tawi 180001

Regional Research Laboratory. *Address:* Jorhat 785006 (AS"AM)

Regional Research Laboratory. *Address:* Industrial Estate, PO Pappanamcode, Trivandrum 659019

Saha Institute of Nuclear Physics. *Address:* 92 Acharya Prafulla Chandra Road, Calcutta 700009, West Bengal

Sardar Vallabbhai Regional College of Engineering and Technology. *Address:* Surat 395007, Gujarat

Schieffelin Leprosy and Training Centre. *Address:* Karigiri 632106, North Arcot District, Tamil Nadu

Space Centre. *Address:* Sriharikota, Andhra Pradesh

Space Applications Centre. *Address:* Ahmedabad 380083, Gujarat

Sugarcane Breeding Institute. *Address:* Lawley road, Coimbatorc 741007, Tamil Nadu

Tea Research Association. *Address:* Tocklai Experimental Station, Jorhat 758008, Assam

Telecommunications Consultants India Limited. *Address:* Chiranjiv Tower, 3rd Floor, 43 Nehru Place, New Delhi 110019

Vector Control Research Centre. *Address:* Medical Complex, Indira Nagar, Pondicherry 605006

Vikram Sarabhai Space Centre. *Address:* Trivandrum 695003, Kerala

Videsh Sanchar Nigam Limited. *Address:* Mahatma Gandhi Road, Bombay 400001, Maharashtra

Voltas Limited Agro-Industrial Products Division. *Address: 19* J.N. Heredia Marg, Ballard Estate, Bombay 400038

Welding Research Institute. *Address:* Tiruchirapalli 620014, Tamil Nadu

Wellcome Research Unit, Department of Gastroenterology. *Address:* Christian Medical College Hospital, Vellore 632004, Tamil Nadu

Zoological Survey of India Eastern Regional Station. *Address:* Fruit Garden, Risa Colony, Shillong 793003, Meghalaya.

UNIT 11 POLICIES

Objectives

After studying this unit, you will be able to understand:

- the basic policy followed by the Government in Science and Technology
- current policies and procedures followed for technology import
- the incentives given by the Government to promote, utilise and transfer technology
- role of various S&T departments
- technology policies followed in some industrialised countries.

Structure

11.1 INTRODUCTION

National policies are an expression of the intentions of the Government to *achieve* a set of objectives. The policies are supplemented by necessary instruments and mechanisms to implement them over a period of time. The government in a country may formulate a number of policies for various purposes for different sectors e.g., `industrial policy' for development and canalization of resources for growth and regulation of industries, `trade policy' for growth and regulation of trade (import-export), `fiscal policy' for allowing tax incentives, `science and technology policy' for promotion & development of S&T etc. The Indian Government for example has also formulated policies for some sectors of the industry such as Textile policy, Electronics policy, Drugs policy, and so forth. The policies however may differ from country to country, depending upon socio-political and other factors. Much of the progress made in the industrialised countries can be attributed to the pragmatic policies pursued in those countries which were reviewed from time to time, as the circumstances warranted.

Among developing nations, India is one of the very few countries which evolved S&T policies as early as in 1958 and devoted considerable attention and resources to the development and promotion of S&T through structured mechanisms in the form of departments, institutions, programmes and activities at government, non-government, and enterprise levels.

You will recall that we had briefly touched upon some aspects and issues relating to S&T in India in the previous units, particularly, the preceding one. We shall now focus our attention, in somewhat greater detail, on the S&T and other relevant 'policies and the issues related thereto, as they impinge upon industrial enterprises.

'Technology policies in some industrial countries have also been briefly reviewed. The implementation and impact of the technology policies in India have been briefly examined.

11.2 S & T POLICIES

The two landmarks in S&T policies are: Scientific Policy Resolution of 1958 and Technology Policy Statement of 1983.

The government first initiated its policy in the form of a Scientific Policy Resolution announced in 1958. This policy recognized the cardinal importance of cultivating science on a large-scale and its application to meet the country's requirements. The aims set out in this policy were:

i) to foster, promote, and sustain by all appropriate means, the cultivation of science, and scientific research in all its aspects-pure, applied and educational;
ii) to ensure an adequate supply, within the country, of research scientists of the highest quality, and to recognize their work as an important component of the strength of the nation;
iii) to encourage, and initiate, with all possible speed, programmes for the training of scientific and technical personnel, on a scale adequate to fulfill the country's needs in science and education, agriculture and industry and defence;
iv) to ensure that the creative talent of men and women is encouraged and finds full scope in scientific activity;
v) to encourage individual initiative for the acquisition and dissemination of knowledge, and for the discovery of new knowledge, in an atmosphere of academic freedom;
vi) and in general, to secure for the people of the country all the benefits that can accrue from the acquisition and application of scientific knowledge.

The policy mentions that to pursue and accomplish the above aims the government had decided to offer good conditions of service to scientists and accord them an honoured position by associating them with formulation of policies and taking such measures as may be necessary from time to time.

Technology Policy Statement 1983

Since the enunciation of the Scientific Policy Resolution in 1958 and the planning process of nearly three decades, the country achieved a strong agricultural and industrial base and scientific manpower impressive in quality, numbers and range of skills. The experience indicated that given the necessary support, the Indian science and technology has capacity to solve many national problems. The changing scenario witnessed extension of frontiers of knowledge at incredible speed, opening up entirely new areas and introducing new concepts. The technological advances were influencing life-styles as well as societal expectations. A need, therefore, was felt for a technology policy to give thrust and future direction, to Indian science and technology. The government therefore enunciated Technology Policy Statement in 1983.

This Policy dealt with various aspects such as self reliance, strengthening of the technology base, environment, development of indigenous technology, in-house research and development, consultancy, technology acquisition and transfer and 'other related issues. The main highlights of this statement were as under:

I) Aims

a) attain technological competence and self-reliance to reduce vulnerability, particularly in strategic and critical areas, making the maximum use of indigenous resources;

b) provide the maximum gainful and satisfying employment to all strata of society, with emphasis on the employment of women and weaker sections of society;

c) use traditional skills and capabilities, making them commercially competitive;

d) ensure the correct mix between mass production technologies and production by the masses;

e) ensure maximum development with minimum capital outlay;

f) identify obsolescence of technology in use and arrange for modernization of both equipment and technology;

g) develop technologies which are internationally competitive, particularly those with export potential;

h) improve production speedily through greater efficiency and fuller utilization of existing capabilities and enhance the quality and reliability of performance and output;

i) reduce demands on energy, particularly energy from non-renewable sources;

j) ensure harmony with the environment, preserve the ecological balance and improve the quality of the habitat; and

k) recycle waste material and make full utilization of by-products.

II) Strengthening the Technology Base

Research and development together with science and technology education and training of a high order were to be accorded place of pride.

III) Environment

Due regard was to be given to the preservation and enhancement of the environment in the choice of technologies. Measures to improve environmental hygiene were to be evolved.

IV) Some Specific Areas

In technology development special emphasis was to be focused on food, health, housing, energy and industry. In partidular, stress was laid on:

- agriculture, including dry land farming;
- optimum use of water resources, increased production of pulses and oilseeds;
- provision of drinking water in rural areas, improvement of nutrition, rapid reduction in the incidence of blindness, eradication of the major communicable diseases (such as leprosy and tuberculosis), and population stabilization;
- low cost housing;
- development and use of renewable non-conventional sources of energy; and
- industrial development.

V) Importance of Technology Development

Fullest support was to be given to the development of indigenous technology to achieve technological self-reliance and reduce the. dependence on foreign inputs, particularly in critical and vulnerable areas and in high value-added items in which the domestic base is strong. Strengthening and diversifying the domestic technology were felt necessary to reduce imports and to expand exports for which international competitiveness must be ensured.

VI) In-house R&D

Appropriate incentives were to be given to the setting up of R&D units in industry and for industry, including those on a cooperative basis.. Enterprises were to be encouraged to set up R&D units of a size to permit the accomplishment of major technological tasks.

VII) Technology Acquisition

Mix of Indigenous and Imported Technology is envisaged.
A policy directed towards technological self-reliance does not imply technological self-sufficiency. The criterion must be national interest. Government policy was to he directed towards reducing technological dependence in key areas.

It was stated that advantage should be taken of technological developments elsewhere. This can also be achieved through well-defined collaborative arrangements in research and development.

At any given point of time, there will be a mix of indigenous and imported technology. However, technology acquisition from outside was not to be at the expense of national interest. Indigenous initiative must receive due recognition and support.

In the acquisition of technology, consideration was to be given to the choice and sources of technology, alternative means of acquiring it, its role in meeting a major felt need, selection and relevance of the products, costs, and related conditions. A National Register of Foreign Collaborations was developed to provide analytical inputs at various stages of technological acquisition.

The basic principles governing the acquisition of technology were:

a) Import of technology, and foreign investment in this regard, were to be continued to he permitted on a selective basis where: need had been established technology did not exist within the country; the time taken to generate the technology indigenously was likely to delay the achievement of development targets.
b) Government from time to time, would identify and notify such areas of high national priority, in respect of which procedures would he simplified further to ensure timely acquisition of the required technology.
c) There was to be a firm commitment for absorption, adaptation and subsequent development of imported know-how through adequate investment in Research and Development to which importers of technology would be expected to contribute.

With a view to implement the above policy, the Government had set up a Technology Policy Implementation Committee (TPIC). Many of the recommendations have since been implemented.

11.3 INDUSTRIAL POLICY

Technology, industry, commerce and finance are closely interrelated and hence the respective policies. The goals and objectives set out for the nation on the eve of independence and embodied subsequently in the Five Year Plans related to rapid agricultural and industrial development, rapid expansion of opportunities for gainful employment, progressive reduction of social and economic disparities, removal of poverty and attainment of self-reliance which even today remain as valid as they were at that time. In 1948, the Industrial Policy Resolution outlined the approach to industrial growth and development. It emphasised the importance to the economy of securing a continuous increase in production and ensuring its equitable distribution.

This Resolution was followed by another Resolution of 1956 which had as its objective the acceleration of the rate of economic growth and the speeding up of industrialisation. The Industrial Policy Statement of 1973, inter alia, identified high priority industries for investment from large industrial houses and foreign companies. In 1977, the emphasis was laid on decentralisation and on the role of small-scale, tiny and cottage industries. In 1980, the attention was focused on the need for promoting competition in the **domestic market,' technology upgradation and modernisation.** This policy laid the foundation for an increasingly competitive export base and for **encouraging foreign investment in high technology areas.**

These policies created a climate for rapid industrial growth and a broad-based infrastructure had been build up incorporating a high degree of self-reliance in a large number of items and a new generation of entrepreneurs. A large number of engineers, technicians and skilled workers had also been trained. A number of policy and procedural changes were introduced in 1985 and 1986 aimed at increasing productivity, reducing costs and improving quality. The accent was an opening the domestic market to increased competition and readying our industry to stand on its own in the face of international competition. The **technological and managerial modernisation** of industry was pursued as the key instrument for increasing productivity and improving our competitiveness in the world. The net result of all these changes was that Indian industry grew at an impressive average annual growth rate of 8.5% in the seventh plan period.

The industrial policy till mid 1991 continued to be restrictive in respect of import. of technology and other related matters. For example, foreign collaborations or import of technologies were permitted in select areas only and on set guidelines (relating to payments, period of collaborations, royalty payment, etc.) and licensing system was followed for the setting up new industrial capacities based mostly on estimates of domestic needs. The statement on Industrial Policy in 1991 has emphasised the policy of self-reliance with focus on building up the ability to pay for imports through foreign exchange earnings. Government is also committed to the **development and utilisation of indigenous capabilities in technology and manufacturing as well as its upgradation to world standards. It** has further emphasised to continue to pursue a sound policy framework encompassing encouragement to entrepreneurship, **development of indigenous technology through investment in R&D, development of the capital market and increasing competitiveness for the benefit of the common man.**

***Statement on Industrial Policy* 1991** lays down that the Government would provide enhanced support to the small-scale sector in an environment of economic efficiency and **continuous technology upgradation.** It states that foreign investment and technology collaborations would be welcome and that high technology to increase export and to expand the production base would be obtained. Intensive training, skill development and upgradation programmes are to be launched. In pursuit of the objectives of 1991 statement the government has decided to take a series of initiatives in respect of the policies relating to the following areas:

- Industrial Licensing
- Foreign Investment
- Foreign Technology Agreements
- Public Sector Policy
- MRTP Act

A package for the Small and Tiny sectors of industry has been announced separately.

Industrial Licensing Policy: According to the new Industrial Policy Statement, industrial licensing has been abolished for all industries, except those specified, irrespective of levels of investment. These specified. industries include a list of 18 sectors such as coal and lignite, petroleum distillation and brewing of alcoholic drinks, sugar, animal fats and oil, tobacco, asbestos, playwood etc., raw hides, skins and leather, tanned or dressed fur skins, motor cars, paper newsprint, electronic aerospace and defence equipment, industrial explosives, hazardous chemicals, drugs

& pharmaceuticals, entertainment electronics, white goods (domestic refrigerators, washing machines, microwave ovens, airconditioners, etc.) Industries reserved for the small-scale sector will continue to be so reserved.

Policy for Small, Tiny and Village Industries: The small-scale industrial sector has emerged as dynamic and vibrant 'sector of the economy during the eighties. At the end of seventh plan period, it accounted for nearly 35% of the gross value of output in the manufacturing sector and over 40% of the total exports from the country. It also provided employment opportunities to around 12 million people. The Government has announced increase in investment limits in plant and machinery for small-scale units, ancillary units and export-oriented units to Rs. 60 lakhs, 75 lakhs, and 75 lakhs respectively, and for tiny enterprises' to Rs. 5 lakhs from Rs. 2 lakhs.

Non-SSI units have been allowed to participate up to 24% in the equity of small-scale units, and also foreign investment (up to a limit) can be made.

Need for technological back up services has been recognised for the small sector. A Technology Development Cell (TDC) would be set up in the Small Industries Development Organisation (SIDO), which would provide technology inputs to improve productivity and competitiveness of the products of the small-scale sector. The TDC would coordinate the activities of the Tool Rooms, Process-cum-Production-Development Centres (PPDCs) and would also interact with other industrial research and development organisations to achieve its objectives. Several measures have been suggested for modernisation, technological and quality upgradation efforts. A greater degree of awareness to produce goods and services conforming to national and international standards would be created among the small-scale sector. Technology information centres and programmes for improving productive and cost-effectiveness would be pursued. Indian Institutes of Technologies (IITs) and selected Regional/other engineering colleges will serve as technological information and design development centres in their respective command areas.

Activity 1

Identify the areas on which stress was laid in the Scientific Policy R esolution 1958.

Areas:

1. ……………………………………………………………………………………
2. ……………………………………………………………………………………
3. ……………………………………………………………………………………

Activity 2

Identify major factors which led to enunciation of Technology Policy Statement 1983.

Main Factors:

1. ……………………………………………………………………………………
2. ……………………………………………………………………………………

Activity 3

Identify areas of stress in the Technology Policy Statement 1983.

Areas

1. ……………………………………………………………………………………
2. ……………………………………………………………………………………

Foreign Investment

i) Approval will be given for direct foreign investment up to 51% foreign equity in high priority industries. The list of such industries is given in Appendix 1. Such clearance will be available if foreign equity covers the foreign exchange requirement of imported capital goods.

ii) While the import of components, raw materials and intermediate goods, and payment of know-how fees and royalties will be governed by the general policy applicable to other domestic units, the payment of dividends would be monitored through the Reserve Bank of India so as to ensure that outflows on account of dividend payments are balanced by export earnings over a period of time.

iii) iii) Other foreign equity proposals, including proposals involving 51% foreign equity which do not meet the criterion under (i) above will continue to need prior clearance. Foreign equity proposals need not necessarily be accompanied by foreign technology agreements.

iv) To provide access to international markets, majority foreign equity holding up to 51% equity will be allowed for trading companies primarily engaged in export activities. While the thrust would be on export activities, such trading houses shall be at par with domestic trading and export houses in accordance with the Import Export Policy.

v) A Special Empowered Board would be constituted to negotiate with a number of large international firms and approve direct foreign investment in select areas. This would be a special programme tp attract substantial investment that would provide access to high technology and world markets. The investment programmes of such firms would be considered in totality, free from predetermined parameters or procedures.

Foreign Technology Agreements

i) Automatic permission will be given for foreign technology agreements in high priority industries up to a lump sum payment of Rs. 1 crore, 5% royalty for domestic sales and 8% for exports, subject to total payments of 8% of sales over. a 10-year period from date of agreement or 7 years from commencement of production. The prescribed royalty rates are net of taxes and will be calculated according to standard procedures.

ii) In respect of industries other than those in the high priority category, automatic permission will be given subject to the same guidelines as above if no free foreign exchange is required for any payments.

iii) All other proposals will need specific approval under the general procedures in force.

iv) No permission will be necessary for hiring of foreign technicians, foreign testing of indigenously developed technologies. Payment may be made from blanket permits or free foreign exchange according to RBI guidelines.

v) The companies are expected to balance or meet their import requirements through their exports or purchase of Exim scrips (foreign exchange entitlement of exporters) from the open market which are available at a premium.

11.4 TRADE POLICY

International trade today, more than ever before, is the driving force of economic activity. It not only enables the exchange of goods and services among countries, but serves. as the bedrock for the increasingly interdependent global network of technology, investment and production. The new trade policy announced in 1991 has recognised the increasing importance to enhance exports to meet import requirements and improve the foreign exchange balance position in the country. Emphasis now appears to be on export driven economy rather than import substitution. Also, exports are mainly in low technology areas such as textiles & . garments, jems & jewellery, handicrafts, tea and marine products; agricultural products, etc. Efforts are now being made to promote technology intensive products, projects and services, and perhaps "technology led exports" rather than "product led exports" could be a slogan in future.

The new trade policy has simplified the procedures of export documentation and several new measures have been taken by the Ministry of Commerce to facilitate exports, including the acceleration of the production of 100% export-oriented units and setting up of export promotion zones. Role of export houses, trading houses, export promotion councils and similar other agencies is being rationalised, including the induction of professionalism in these organisations. The government promotional agencies such as Trade Development Authority (TDA), Trade Fair Authority of India (TFAI), Indian Institute of Foreign Trade (IIFT), etc are also being restructured or redefined. National Small Industries Corporation (NSIC) is to play a pivotal role for exports from small sector. Technology is being increasingly recognised as an important factor in building up export capabilities and manufacture of exportable products. The role of the official technology information system experts in reduction of imports cannot be overemphasised. The Ministry of Commerce is said to be considering the establishment of an information centre for this purpose. Establishing joint ventures abroad by Indian enterprises is another route for promoting Indian exports of technologies, projects and services.

11.5 EDUCATION POLICY

Education policy and S&T policies are closely related to each other. An important objective of technology oriented institutions is to provide qualified S&T manpower for development tasks. Institutions like IITs, Indian Institute of Science-Bangalore, Birla Institute of Technology (BITS)-Pilani also conduct research, mostly of generic nature, and provide specialised consultancy services to industry. In India, during 1987-88, there were 174 universities which include 142 universities as much, 22 deemed universities and 10 institutes of national importance. Pure science doctorates had a share of 73.2% of total 4010 S&T doctorates produced 'during 1986-87. It is reported that as on April 1, 1988, 2.68 lakh S&T personnel were employed in R&D establishments. By nature of work, 36.2% were engaged in R&D activities, 30.3% were performing ancillary activities and. 3.23% were providing administrative support. Out of 96927 personnel engaged in R&D activities, 65782 were employed in institutional sector and the rest 31145 were employed in R&D units of public and private industries. The share of engineers was 45% among total R&D personnel.

Apart from university system, engineering colleges, industrial training institutes, specialised training institutes set up by various Ministries (such as Electronics, -Telecommunication, Labour, Industry) also provide trained technical manpower to industry. Other ministries/departments such as DST/DBT, DUE, also fund R&D projects of academic institutions. It has however been observed in the recent past that the Ministry of Education (Human Resource Development) is not able to provide adequate funds to modernise the teaching facilities and it is being argued that industry should support such facilities since it is one of the main beneficiaries.

11.6 OTHER POLICIES

In the previous unit we acquainted you with how the activities of S&T in India are organised. The structure consists of various departments and specialised agencies in the Ministry of Science & Technology. While the Ministry of Science & Technology has the general responsibility of coordinating the overall development of S&T, many of the economic Ministries also have budgetary outlays for technology related activities and have evolved their own policies which have a technology component. Examples of this nature include Housing Policy, Textile Policy, Drug Policy, Fertilizer Policy, Steel Policy, Cement Policy, Energy Policy, Labour Policy, etc.

Some of them may be explicit and some implicit in the functioning of the respective departments.

The policies in various departments related to S&T include Electronics, Computers and Software, Space, Atomic Energy, non-conventional sources of energy, Pollution Control and Environment, besides the Technology Policy mentioned earlier. All these policies have been evolved over a period of time and implemented through various mechanisms set up for the purpose. However, the experience has been that the end results have been generally far from satisfactory, and much more is desired at implementation stages. One of the reasons could be the lack of coordination and consultation mechanism among various departments of the Government as well as the incoherence in the political and bureaucratic systems. There is often overlapping of functions and policies in various departments as well as delays in decisions. For example, policies related to development and manufacture of computers, VCRs, TVs etc.took enormous time at the Government level. At times, the time gap between the applications for licensing (or required approvals), import of technologies and the decision made on them by the Government was so large that the technology itself got outdated and the applicant had to often seek another technology. The delays could also result in cost escalations which could adversely affect the technical/technological inputs of the project. This may appear to be overstating a point, but the idea is to convey that the delays in implementation of policies were large.

The new policies of 1991 however have attempted to correct or better the situation. Hopefully, the implementation of the new policies would take care of the adverse past experiences and the enterprises would be confronting an efficient and result oriented system in the near future. The trade policies have a direct bearing on the technology development plans at the company level because the lists of products/items announced by the Government for import-export and associated duty structures are important in deciding the product mix, market strategies and other issues.

At times, the technology promotion and trade promotion policies could be in conflict .instead of being complementary to each other. Such distortions need to be taken care of in, the technology management programmes at all levels. Similarly, other policies also need to be framed in, such a manner that these are conducive and helpful to each other in their implementation.

11.7 INCENTIVES AND SUPPORT MECHANISMS

Fiscal incentives and tax concessions are some of the measures adopted in several developed and developing economies to encourage and promote industrial research and technology development at the enterprise level. The extent and mode of these measures may vary from country to country. Fiscal incentives are often integrated with technology or other relevant policies. In India, the Government has provided several fiscal incentives and tax concessions to promote industrial research in industry by industry, which aim at achieving greater degree of self-reliance and technological competence. These measures are in addition to direct/indirect funding by the Government for R&D projects and activities of R&D organisations and academic institutions engaged in R&D activities of relevance to industry. Various departments providing such funds include Departments of Electronics, Space Environment, Non-conventional sources of energy, Science & Technology and Biotechnology. The Department of Scientific & Industrial Research (DSIR) is mainly concerned for the promotion of industrial research in industry by industry across the entire industrial sector, and has evolved several schemes towards this objective.

Encouragement to Research and Development

Industrial research and development is the backbone of technology generation and absorption. With a view to encourage indigenous R&D in industry, the Government has provided a number of concessions. Apart from the scheme for granting. . recognition to in house R&D units in the industrial sector and private or public funded research and development laboratories by the Department of Scientific and Industrial Research (Which we discussed in the previous unit). Other incentives provided for are:

i) **Import facilities** have been provided to recognized R&D units. All such units could import their full requirements of technical and professional equipments, raw materials, components, spares and other items on open general licence, subject,however, to the actual user conditions.

ii) All Scientific and Technical instruments, operation accessories (excluding consumable items) imported by the research institutions are **exempted from payment of custom duty** subject, however, to certain conditions.

iii) Under Section 35(1)(i) of the Income Tax Act, the revenue expenditure laid out or expended on scientific research, by the in-house R&D unit on activities related to the business of the company, is allowed as full deduction. Where such expenditure has been laid out or expended before the commencement of the business, such expenditure incurred within the three years immediately preceding the commencement of the business could also be deemed to have been expended in the previous year in which the business is commenced.

Under Section 35 (2) of the Income Tax Act the expenditure of capital nature on scientific research incurred after 31.3.1967, related to the business carried on, could be deducted totally from the income of the year in which this expenditure is incurred. Further, where such capital expenditure has been incurred before the commencement of the business, the aggregate expenditure so incurred within the three years immediately preceding the commencement of the business shall also be deemed to have been incurred in the previous year in which the business is commenced build up national strength in purchasing only competitive and selected components of technology.

To achieve above objectives, DSIR had initiated following activities during 8th Plan:

a) Compilation and study of basic data for foreign collaborations approved.
b) Follow up of the implementation of foreign collaborations approved.
c) Analytical studies of technological, economic and legal aspects of FCs.
d) Preparation of reports on technology status in identified sectors/products. About100 such reports have been prepared.
e) Completion of directory of experts on technology imports.

Transfer and Trading in Technology (TATT)

Exports are essential to earn foreign exchange. Export of technologies, projects, and services from India could be an important source of earning foreign exchange. Technological and industrial experience and capabilities of India could be of relevance to other developing countries. Keeping this in view and to provide a conducive atmosphere for the marketing of indigenous technology, whether in embodied or disembodied form, a scheme on "Transfer and Trading in Technology" was formulated towards the end of 6th plan. The activities under this Scheme included:

a) Documentation of exportable technologies and technological capabilities from export point of view.
b) Preparation of technology profiles for target developing countries,. with special emphasis on identification of their technological needs.
c) Dissemination and publicity of technological capabilities through a variety of measures in the form of reports/publications, video films, brochures, workshops, training programmes, and exhibitions.

DSIR has prepared several reports and provided assistance to export promotion agencies to export technologies from India. Export of technologies is considered to be far more difficult than products, but at the same time it is far more rewarding in terms of continuing exports of products and services, besides recurring royalty and know-how fees. Indian companies have not so far adequately realised and developed capabilities to export technologies in a meaningful manner. Setting up of joint ventures by Indian Companies abroad, is another form of technology exports and over 190 such ventures have been set up in several countries. However, the performance and the returns from these ventures are yet to be made more satisfactory. Several studies have been carried out to study the performance of Indian joint ventures abroad which have also indicated that Indian companies have also performed better in domestic markets through their joint ventures. Success stories of South Korea, Taiwan, Singapore, and Japan also support such conclusions. It is therefore in the long-term interest of the companies which develop adequate capabilities and strategies to export their know-how and services abroad.

11.8 TECHNOLOGY SUPPORT AND MODERNISATION IN SMALL - SCALE SECTOR

Considerable importance is being given by the Government to the technological developments and modernisation in the small-scale sectors. The Development Commissioner, Small Scale Industry has a programme for modernisation which envisages upgradation of obsolete technology through identification of input needs of small-scale industries in rural urban and backward areas and guiding them to get optimum inputs from various organisations to the maximum possible extent. The main objectives of the modernisation programme are:

i) Improvement in production technology.
ii) Product development and design.
iii) Testing and quality control.
iv) Machinery and equipment.
v) Selection of proper raw materials.
vi) Application of improved management techniques.

The units opting for modernisation get themselves registered with the Small Scale Industry Organisation on payment of a nominal registration fee. On registration of the units, detailed studies are conducted to assess the modernisation needs of the individual units. They are then assisted to implement the recommendations by the experts in the field.

The Industrial Development Bank of India (IDBI) has also a scheme for providing concessional finance to units under modernisation scheme and has recently evolved "UPTECH" programme for upgradation of technology. The Industrial Finance Corporation of India (IFCI) also operates a scheme of subsidy for encouraging the modernisation of tiny and ancillary units.

For the benefit of the small-scale units, a number of product and process development centres have been established and more are in the process of being set up. A few of these are:

1) The Products and Process Development Centre for Glass & Ceramic Industries, Ranchi.
2) Process-cum-Products Development Centre for Sports Goods and Leisure Time Equipment, Meerut.
3) Process-cum-Product Development Centre for Foundry and Forging Industries, Agra.
4) Institute for Design for Electrical Measuring Instruments, Bombay.

5) Electronic Service and Training Centres at Ramnagar (U.P.).
6) Small Scale Services Industries Centres (SSIC), National Small Scale

Industries Corporation (NSIC) etc. under the Department of Small Industries provide technological support and guidance.

11.9 S&T POLICIES IN SELECT DEVELOPED COUNTRIES

Now, we will acquaint you with the main features of technology policies and programme of two developed countries, viz., United States of America and Japan.

United States of America (USA)

Based on a general consensus, the Government's involvement in the USA in science and technology is to overcome market failures-specially low appropriability and capital market imperfections-that cause underinvestment in R&D. Traditionally, the US Government only supports scientific research and academic engineering, mainly through the National Science Foundation (NSF), and well-defined mission oriented programmes in which Government has strong and direct procurement interest.' As is well-known, Federal government there basically follows free market principles and is not so much concerned with distributional aspects. It depends largely on tax and regulatory framework to improve the climate and involvement for innovation. The Government leaves commercial technology development to private industry.

In the federal executive branch, the mission agencies-most notably, the Department of Energy (DOE) and Department of Defence (DOD) and the National Aeronautics and Space Agency (NASA)-are the major players in mission oriented R&D. These agencies have operational responsibilities that mandate rather immediate operating goals and put the agencies under constant pressure to produce results in a tangible way to justify their existence. NSF mainly sponsors general purpose basic research and is responsible for the health of the basic science community, the special universities and non-profit research institutes. It has also promoted applied research through programmes, such as Inter disciplinary Research, Relevant to Problems of Society (IRRPOS), Research Relevant to Problems of Society (RRPOS), Research Applied to National Needs Programme (RANN), launched in 1968 and 1972 respectively. The office of Industrial Technology, established in 1980 in the Department of Commerce, is involved in innovation policy. In the area of IndustrialTechnology Policy, basically speaking, the US has been following a mission oriented approach. In general the US lacks a comprehensive, strategically oriented approach as compared to Japan and many European countries'.

In the recent past there have been some more serious initiatives for encouraging innovations and technology development, in order to regain the competitive strength in international markets. Under the Reagan Administration, integration of economics and science and technology was generally emphasised with a view to enhancing industrial competitiveness. Many special programmes including those related to Defence were launched. Under the new philosophy, several programmes, such as very high speed integrated circuits, semi-manufacture of conductor devices and materials research consortium, high definition television were initiated as mission oriented programmes. In the Bush Administration, the first technology policy statement-US Technology Policy-was published in 1990 and delivered to the US Congress'. In this document, some advanced technological fields, such as robotics, semi-conductors, super conductivity and advanced imaging technologies have been targeted. Other areas, such as biotechnology, alternative energy and transportation, are also identified. This Policy Statement includes Government participation in pre-competitive research on generic technologies that have the potential to contribute to a broad range of Government and commercial applications. It is reported that US Industrial Technology Policy is presently undergoing a structural change[4]. Figure

11.1 indicates US Mission Oriented and Trickle Down Strategy for industrial technology.

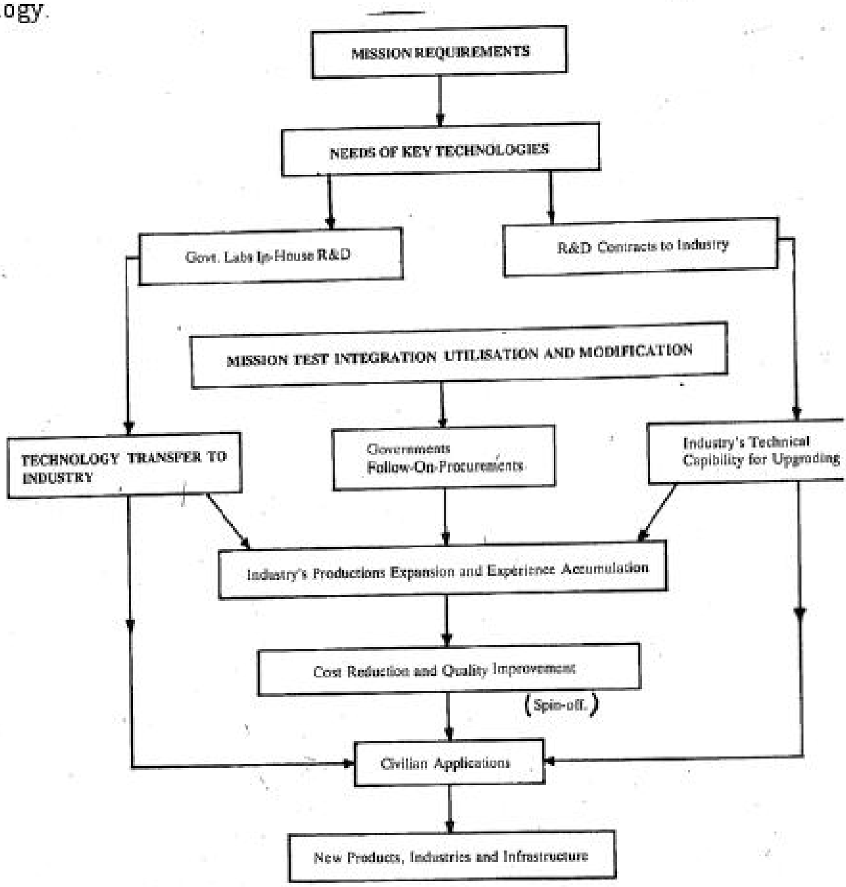


Fig. 11.1: Mission-oriented and Trickle Down Strategy for Technology in USA

Source: Chiang, Jang-Tsang, Sept., 1991, From Mission-oriented to Diffusion-oriented paradigm : the, New Trend of U S Industrial Technology Policy Technovation, pp 340

Japan

Iin the 1950s and through to the mid 1960s the main policy centred on facilitation of the importation of technology[6]. However, in the mid 1960s the emphasis had shifted to promote domestic R&D and various policy measures like tax breaks, subsidies and research contracts were employed to encourage R&D in private firms. In the 1970s, public policy became more selective, and R&D on pollution control, energy, space and ocean resources was encouraged. During late 1980s, the policy discussion centre ,around the problem of how to enhance Japan's technology base in basic technologies in order to promote a shift to high-technology production. Preferential tax treatment, subsidies, research contracts, low interest loans, establishment of public research institutions, public corporations, and research associations were considered some of the measures in this direction. It is argued' that Japanese Technology Policy worked side by side with the market forces rather than replacing them with the political process. This approach was considered to be successful in the sense that it contributed to the 'promotion of technological progress and a high rate of economic growth. Japan spent 6503 billion Yen on R&D and 370,000 researchers were engaged in 1983. Less than a quarter of this R&D expenditure was funded by the Government. Small and medium enterprises always occupied an important place in the economy and development policies of Japan. Figure 11.2 indicates Japan's Technology Policy for small and medium enterprises.

According to Akiro Goeto and Ryuhli Wakasugi,' in the 1980s the technological innovation.in high-technology industries became one of the main thrusts of Technology Policy. To achieve technological innovation in these fields, it is of critical importance to build up the basic research base, and technology policy must concentrate on creating favourable conditions to promote basic R&D activity. From the experience of Japan, it will be noted that favourable conditions to promote research or R&D activity cannot be achieved by simply increasing the government allocation to universities, research institutes, and public corporations, nor by increasing the government subsidy to the private sector. To promote basic and creative R&D, a dynamic and innovative government policy is needed. Science and TechnologyPolicyEducation and Training Policy Small and Medium Enterprise (SME) Technology Policy

	Nat'l Gov't	Local Gov't	Nat'l Labs	Local Labs	SME Corp	SME Insuran
Technical Consulting		X		X	X	
Technical R&D	M	M	X	X	X	M
Technical Training		X			X	
Technical Information				X	X	
Technology Transfer		X			X	
Regional Specific		X			X	

Notes: X Major responsibility M : Financial support **SME** Corp.: Small and Medium Enterprise Corporation under Central Government Small & Medium Enterprise Agency's sponsorship SME Insunmce Smull and Medium Enterprise Credit Insurance Bank. . Government's Support for Government's Support for SMEs in Subcontracting Systems SME Collective Practices with Big Enterprises

• Production + Fair Transaction Code - Industrial Parks between Big Enterprises -- Common Factories and SMEs + 'Transportation Stations

- Modernization of SMEs • Warehousing

Loan + Other Common Facilities

Insurance - Anti-Pollution

Quality Control - Energy Saving

Value Analysis - Computing

Industrial Engineering - Housing ;

Zero Defect Operation - Secretary Service

Industry-Specific Assistance - Recreation

- Organization of Subcontracting

Association of SMEs

Fig. 11.2 : Japan's Technology Policy for Small and Medium Enterprises

Source: Chiang, Jang-Tsang, Sept., 1991, From Mission-oriented to Diffusion-oriented paradigm : the-, New Trend of U S Industrial Technology Policy, Technovation, pp. 351

11.10 SUMMARY

Science and Technology have been given a pivotal role in the development and planning process in the country. While the Scientific Policy Resolution of 1958 laid stress on development of scientific and technical personnel, the Technology Policy State of 1983 covered various facets intended for accelerated growth of science and technology in India. The statement of Industrial Policy 1991 was liberalised industrial licensing, import of technology and encourages foreign equity participation and automatic approval for foreign technology agreements in specified industries. A number of incentives have been evolved by the Government for technology generation, absorption, adaptation, R&D in industry and other related aspects. Trade, finance and other policies such as those relating to electronics & computers, telecommunications, housing, energy, textiles have close relationship with technology policy. All such policies need to be coordinated with technology policy to encourage and promote more effective technology development and management programmes at the enterprise level. Government has specifically brought out a policy for small and tiny sector in which technology occupies an important place. While several departments of the Government at the centre and states provide support and encourage S&T, the DSIR has a specific role to promote

and catalyse R&D inindustry. The companies can take advantage of the schemes and support available from DSIR and other departments.

We briefly discussed S&T policies in the USA and Japan with special reference to R&D in industry. These countries have evolved S&T policies, specially to encourage participation of industrial sector in innovations and development of technologies with a view to achieve comparative advantages in markets. The governments in these countries offer several fiscal incentives and tax concessions to stimulate industry to spend more and more on R&D.

In the context of new policy environment in India, the S&T policies also need to be reviewed to take into account the emerging requirements of the industry. Implementation mechanisms need to be made more effective so as to create favourable technology environment for the firms to invest more in R&D.

11.11 KEY WORDS

Policies: Expressions of intentions of a government for its future actions to achieve a set of objectives.

Policy Resolution: A policy resolution adopted in 1958 to nurture and develop science and its applications to meet national requirements.

Technology Policy Statement: A Policy Statement adopted in 1983 to promote and develop technologies to meet the aspirations of all sections of society.

Technology Policy Implementation Committee (TPIC): A Committee to advise on appropriate mechanisms and measures to implement the TPS.

Industrial Policy: A policy to promote the development of industries, including small-scale sector.

Trade Policy: A policy for promotion of trade (import-export). It sets the guidelines for duty structure/tariff on import or export of goods and services, besides other related issues.

Fiscal Policy: A policy concerned with management of finance including generation of revenues and incurring of expenditures for various sectors in the country.

Fiscal Incentives: Incentives in the form of tax concessions, duty concessions, and financial benefits provided by the government for encouraging certain activities, e.g. R&D, and technology development.

Support mechanisms: Mechanisms and measures in the form of programmes/ schemes/institutional set ups etc. to promote for R&D and technology development.

Small Industries: Industries having investment of less than Rs. 60 lakhs in plant and machinery as per the new policy announced in 1991.

11.12 SELF-ASSESSMENT QUESTIONS

1) "The key to national prosperity lies in the effective combination of technology, raw materials and capital." Comment.

2) "A policy directed towards technological self-reliance does not imply technological self-sufficiency." Explain.

3) "At any given point of time, there will be a mix of indigenous and imported technologies." Could this be applicable to industrially advanced countries also?

4) What impact a liberal policy on import of technology could have on the indigenous development of technology?

5) "Various policies such as those relating to industry, trade, finance, should be linked to technology *policy* for effective results." Comment.

6) Technology development is a corporate function and would be largely governed by marked forces in their respect. Do you agree with this?

7) Small-scale sector needs special technology support and measures as it is not able to spend adequately on R&D from its limited resources. Comment. Also discuss the S&T facilities available to this sector, especially for modernisation and technology upgradation.

8) Discuss the new Trade Policy briefly with special reference to role of technology in increasing exports and reducing imports.

9) What are the policies, besides S&T and industrial policies? Briefly discuss their role with respect to S&T policies.

10) Discuss any two schemes of DSIR's technology promotion programmes with

their possible advantages to your company or any company that you know of.

11) What R&D incentives are available in developed countries that you might be aware of? In what way have they contributed to technology development in those countries?

11.13 FURTHER READINGS

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7) Ibid B) Ibid **tkppendix**

List of Industries for Automatic Approval of Foreign Technology Agreements and for 51% Foreign Equity Approvals

1) Metallurgical Industries

i) Ferro alloys.

ii) Castings and forgings.

iii) Non-ferrous metals and their alloys.

iv) Sponage iron and pelletisation.

v) Large diameter steel welded pipes of over 300 mm diameter and stainless steel pipes.

vi) Pig iron.

2) Boilers and Steam Generating Plants

3) Prime Movers (other than electrical generators)

i) Industrial turbines.

ii) Internal combustion engines.

iii) Alternate energy systems like solar wind etc. and equipment therefor.

iv) Gas/hydro/Steam turbines up to 60 MW.

4) Electrical Equipment

i) Equipment for transmission and distribution of electricity including power and distribution transformers, power relays, HT-switch gear synchronous condensers.

ii) Electrical motors.

iii) Electrical furnaces, industrial furnaces and induction heating equipment.

iv) X-ray equipment.

v) Electronic equipment, components including sub-scribers' and telecommunication equipments.

vi) Component wires for manufacture of lead-in wires.

vii) Hydro/steam/gas generators/generating sets up to 60 MW.

viii) Generating sets and pumping sets based on internal combustion engines.
ix) Jelly-filled telecommunication cables.
x) Optic fibre.
xi) Energy efficient lamps and
xii) Midget carbon electrodes.

5) Transportation

i) Mechanised sailing vessels up to 10,000 DWT including fishing trawlers.
ii) Ship ancillaries.
iii) a) Commercial vehicles, public transport vehicles including automotive commercial three-wheeler jeep type vehicles, industrial locomotives.
b) Automotive two-wheelers and three-wheelers.
c) Automotive components/spares and ancillaries.
iv) Shock absorbers for railway equipment and
v) Brake system for railway stock and locomotives.

6) Industrial Machinery

i) Industrial machinery and equipment.

7) i) Machine tools and industrial robots and their controls and accessories.
ii) Jigs, fixtures, tools and dies of specialised types and cross land tooling, and
iii) Engineering production aids such as cutting and forming tools, patterns and dies and tools.

8) Agricultural Machinery

i) Tractors.
ii) Self-propelled harvest or combines.
iii) Rice transplanters.

9) Earth Moving Machinery

i) Earth moving machinery and construction machinery and components thereof.

'10) Industrial Instruments

i) indicating, recording and regulating devices for pressure, temperature, rate of flow weights levels and the like.

11) Scientific and Electromedical Instruments and Laboratory Equipment.

12) Nitrogenous & Phosphatic Fertilizers falling under

i) Inorganic fertilizers under `18-Fertilizers' in the First Schedule to IDR Act, 1951.

13) ("herrwinals (other than fertilizers)

i) 1 leavy organic chemicals including petrochemicals.
ii) heavy inorganic chemicals.
iii) Organic fine chemicals.
iv) Synthetic rc;sins and plastics.
v) Man-made fibres.
vi) Synthetic rubber.
vii) Industrial explosives.
viii)'1'echuicaal grade insecticides, fungicides, weedicides, and the like.
ix) Synthetic detergents,
x) Miscellaneous chemicals (for industrial use only)

a) Catalysts and catalyst supports. I)) Photographic chemicals.
c) Rubber chemicals.
d) Polyols.
e) Isaacyanates, urethanes, etc.
f) Speciality chemicals for enhanced oil recovery.
g) Heating fluids.
h) Coal tar distillation and products therefrom.
i) Tonnage plants for the manufacture of industrial gases.
j) High altitude breathing oxygen-medical oxygen.
k) Nitrous oxide.
I) Refrigerant gases like liquid nitrogen, carbon dioxide etc. in large volumes.
m) Argon and other rare gases.

n) Alkali/acid resisting cement compound.
o) Leather chemicals and auxiliaries.
14) Drugs and Pharmaceuticals, According to Drug Policy.
15) i) Paper and pulp including paper products.
ii) Industrial laminates.
16) i) Automobile tyres and tubes.
ii) Rubberised heavy duty industrial beltings of all types.
iii) Rubberised conveyor beltings.
iv) Rubber reinforced and lined flit-fighting hose pipes.
v) High pressure braided hoses.
vi) Engineering and industrial plastic products.
17) Plate Glass.
i) Glass shells for television tubes.
ii) Float glass and plate glass.
iii) H.T. insulators.
iv) Glass fibres of all types,
18) Ceramics.
i) Ceramics for industrial uses.
19) Cement Products.
i) Portland cement.
ii) Gyps= boards, wall boards and the like.
20) High Technology Reproduction and Multiplication Equipment
21) Carbon and Carbon Products.
i) ' Graphite electrodes and anodes.
ii) Impervious graphite blocks and sheets..
22) Pretensioned High Pressure RCC Pipes.
23) Rubber Machinery.
24) Printing Machinery.
i) Web-fed high speed offset rotary printing machine having output of 30,000 or more impressions per hour.
ii) Photocomposing/typesetting machines. #
iii) Multi-colour sheet-fed offset printing machines of sizes of 16(25 and above.
iv) High speed rotogravure printing machines having output of 30,000 or more impressions per hour.
25) Weldifig Electrodes other than those for welding Mild Steel.
26) Industrial Synthetic Diamonds.
27) i) Photosynthesis improvers.
ii) Genetically modified free living symbiotics nitrogen fixer.
iii) Pheromones.
iv) Bio-insecticides.
28) Extraction and Upgrading of Minor Oils.
29) Pre-fabricated Building Material.
30) Soya Products.
i) Soya texture proteins.
ii) Soya protein isolates.
ill) Soya protein concentrates.
Iv) Other specialised products of soyabean.
v) Winterised and deodourised refined soyabean oil.
31) i) Certified high yielding hybrid seeds and synthetic seed and
ii) Certified high yielding plantlets developed through plant tissue culture.
32) All food processing industries other than milk food, malted foods, and flour, but excluding the items reserved for small-scale sector.
33) All items of packaging for food processing industries excluding the items reserved for small-scale sector.
34) Hotels and tourism-related industry.

UNIT 12 LINKAGES

Objectives

After studying this unit, you will be able to:

- have an appreciation of the S&T institutional framework in India
- know about the various. UN and other international agencies concerned with technology development and technology transfer
- understand the need for linkages among industry, institutions, R&D organisations, government agencies, international organisations, etc.
- know the existing linkages with particular reference to technology management in India.

Structure

12.1 INTRODUCTION

After reading the preceding two units of this Block, you must have developed a feeling that a fairly vast and well laid out science and technology infrastructure including policies and institutional mechanisms have been developed in India over the years. It is advisable to take advantage of the existing policies and infrastructural facilities for effective utilisation of investments in technology. Since technology development and technology transfer are costly propositions, it is unlikely that : individual organisation would be self-dependent. The organisations concerned with technology management should therefore build and develop linkages with institutions and other promotional agencies, to take advantage of the facilities and expertise already available. The effective technology management calls for development, transfer and utilisation of technologies at minimum cost so as to make the processes/products most competitive in the market place.

12.2 NATIONAL INSTITUTIONS

As mentioned earlier, a strong institutional framework has been developed in India over the years for the promotion and development of science and technology. The Ministry of Science and Technology of the Government of India is the nodal agency for promotion and development of science and technology in the country as a whole, which is under the direct *charge* of the Prime Minister being the Minister of Science and Technology also. The Departments under the Ministry of Science & Technology Include Department of Science & Technology (DST), Department of Scientific & Industrial Research (DSIR), Department of Biotechnology (DBT). In addition, there are specialised S&T departments and agencies, such as, Department of Atomic Energy, Department of Space, Department of Ocean Development, Defence Research & Development Organisation, and various' R&D centres and organisations under several economic ministries. The Council of Scientific & Industrial Research

(CSIR) under Ministry of Science & Technology, constituted in 1942, is a multidisciplinary and multidimensional organisation with a network of 40 national laboratories/institutes, two research associations, three regional complexes, nine poly-technology transfer centres and over 100 extension centres. The major functions of CSIR include collection and dissemination of S&T information, technology generation, absorption and transfer.

There are several other R&D institutions and agencies in the country including cooperative research centres, research associations, and in-house R&D centres in industry, as was mentioned in a previous unit. India's university system is also another main source for providing inputs for development and transfer of technologies. There are over 140 universities, 25 institutions deemed to be universities and about 7000 colleges. The five Indian Institutes of Technology; Jawaharlal Nehru University, New Delhi; Indian Institute of Science, Bangalore, are some of the major academic institutions engaged in research and development activities in addition to their academic programmes, and are expected to maintain **interaction** to the industry and the government in the area of technology.

The R&D organisations, academic institutions and other scientific organisations have equipped themselves with considerable expertise and infrastructural facilities in terms of equipments, testing facilities, design engineering capabilities, and so on. In fact, these are the institutions which keep themselves abreast with the latest developments taking place elsewhere in the area of science and technology.

Activity 1

Identify three national S&T Institutions or Research Laboratories and three corresponding sectors of Industry for possible linkages.

SI. No	Name of the Institution	Industry	Sector	Type of Possible Linkages

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12.3 INTERNATIONAL AGENCIES

There are several international agencies engaged in the promotion of S&T cooperation among developing and developed countries. Some of the important UN organisations engaged in the development of technological capabilities at national level and promotion of technical cooperation among various countries, include UNESCO (United Nations Educational, Scientific & Cultural Organisation), ILO (International Labour Organisation), WHO (World Health Organisation), UNEP (United Nations Environment Programme), FAO (Food & Agriculture Organisation), UNIDO (United Nations Industrial Development Programme), World Bank, UNDP (United Nations Development Programme), UNCTAD (United Nations Conference on Trade and Development), ESCAP (Economic & Social Commission for Asia and the Pacific), etc. The national governments and institutes/organisations of excellence in various countries have also developed linkages and formal arrangements with their counterparts in other countries.

Regional cooperation is also fostered through agencies like the Commonwealth Science Council, Association of Science Cooperation in Asia, and the World Association for Industrial and Technological Research Organisations, etc. India also provides consultancy services to UNDP and UNIDO in many areas, and has also set aside as much as 10% of its total planned budget (known as Indicative Planning Figure) for this cooperation. A major decision to foster regional and south-south cooperation was taken during the 1981 deliberations of the Pondificial Academy of Sciences, Vatican (Italy), largely through the efforts of some leading scientists of the developing countries (Pakistan, India, Kenya, etc.). Accordingly, the UN officially established on July 5, 1985 the Third World Academy of Sciences (TWAS) in Trieste, Italy, CSIR has several cooperation programmes with the Commonwealth Science Council (UK) in its regional rural technology and meteorology programmes for Asia and the Pacific; with UNESCO in regard to Inter-Governmental Oceanographic Commission; CFTRI (Central Food and Technology Research Institute, Mysore) with the UN University (UNU), Tokyo for advanced training and research in post-harvest technology, bio-technology and micro-electronics.

A similar arrangement exists with IRDC (International Research & Development Centre) Canada. Some of the CSIR institutes conduct training courses for science and technology for SAARC countries in areas like ground water exploration, food processing, medicinal plants, low cost housing materials, leather industry, pesticides, information processing and documentation, etc. Besides, CSIR accepts individual trainees from other countries under sponsorship of UN agencies, IDRC, CFTC (Commonwealth Fund for Technical Cooperation), etc. CSIR is also the implementation agency for UNIDO's Transfer of Technology Programmes between developing countries (Digned in 1982). Under this programme, experts from several Asian, African and Latin American nations have visited India for technology transfer in areas like drugs and pharmaceuticals.

12.4 INTERNATIONAL COOPERATION

India has strongly supported international collaboration in science and technology and has shared its reservoir of expertise, its infrastructure including training facilities with other nations. We have a large number of on-going bilateral and multi-lateral cooperation programmes in science and technology. DST, having nodal responsibility of coordinating international S&T collaboration, provides support and guidance on interaction with other countries and international bodies on programmes of scientific; technological and economic development. These international S&T arrangements currently with about 45 developed and developing countries facilitate the objective of exploring and identifying mutuality of interests as partners, in terms of concrete bilateral and multi-lateral programmes. Such arrangements are of the nature of holding joint workshops, collaborative research programmes, advance R&D training of scientific manpower, exchange of scientists and building-up of S&T infrastructure. A list of some of the countries with whom S&T collaboration agreements have been made is given in Appendix I, along with the indicative areas of collaboration.

India has been actively involved in science and technology development programmes run by UN and other international agencies mainly to strengthen its technological capabilities in identified sectors and sharing its expertise and capabilities with other developing countries. Several international institutions such as, Asia & Pacific Centre for Transfer of Technology (APCTI') at Bangalore, Indo-French Centre for Promotion of Advanced Research at New Delhi, Centre for Science & Technology of Non-Aligned and other developing countries at New Delhi (NAM Centre), International Centre for Genetic Engineering & Biotechnology (ICGEB), New Delhi have been set up in India with the support of international agencies. The Govt. of India has evolved a special programme known as "Technical Cooperation with Developing Countries (TCDC)", under which fellowships are awarded to S&T personnel from Africa and Latin America and also necessary support in terms of training, transfer of technology, etc.; is provided as needed by other countries.

Collaboration programmes with USA & USSR are of significance. The collaborative programmes with USA include new areas, such as fibre-optics, digital electronics, materials science, biotechnology and computers. Collaborative programmes are also in progress)· under STI (Science & Technology Initiatives) of National Science Foundation, USA, With USSR, Integrated Long-term Programme of Cooperation in Science & Technology between India and USSR (ILTP) has been in operation for last few years for the period ending 2000 AD. The areas of cooperation include materials, metallurgy, biotechnology, electronics, chemical industry, etc.

Activity 2

Identify three countries where India's S&T cooperation agreements exist, and indicate possible areas of cooperation with each of them, indicating the reasons thereof.

Sl. No.	Name of the Country	Possible Area of Cooperation	Objectives/ Reasons

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12.5 TRADE AGREEMENTS AND PROTOCOLS

The Govt. of India has formal arrangements for trade and commerce with several developed and developing countries, on bilateral and multi-lateral basis, identifying areas of mutual interest including production technologies, training, exchange of information, organising trade fairs and exhibitions, etc. Trade partners include Afghanistan, Nepal, Bhutan, Iran, Bangladesh; East Asian Region with countries like Thailand, Malaysia, Indonesia, Philippines, Japan, Australia, New Zealand, South Korea, China, Singapore; West European countries including EEC (European Economic Comrirunity)-Belgium, Denmark, France, FRG, Greece, Ireland, Italy, Netherlands, UK, Spain, Portugal; Norwegian countries including Austria, Finland, Norway, Sweden, and Switzerland and other countries, namely, Turkey, Malta and Cyprus. There are trade agreements and trade protocols with East European countries, such as, USSR, GDR, Czechoslovakia, Poland, Romania, Yugoslavia, Hungary, Bulgaria, USA, Canada, Latin America and Caribbean are also major trade partners of India. Trade relations also exist with West Asian and North African Countries (WANA) and Sub Sahara Africa. There are several joint commissions and joint business councils with many of the above countries which also deal with cooperation in manufacturing technologies and transfer of technologies.

12.6 INDUSTRY ASSOCIATIONS AND PROMOTIONAL AGENCIES

There are several industrial associations, such as, Confederation of Engineering Industries (CEI), Federation of Indian Chambers of Commerce and Industry (FICCI), Association of Chambers of Commerce and Industry (ASSOCHEM) etc. which are formed mainly by various industries to represent their interests to the govt. and also provide a link between govt. and industry. Many of these organisations have information/data bases concerning trade and technology, and organise technology-oriented programmes for the benefit of the industry from time to time. CEI has recently started Total Quality Management Programmes (TOM) to educate the industry about the technological and quality requirements at international levels and also how to achieve those standards for Indian products. The Govt. has set up several specialised facilities, such as, training centres, test and development centres, advanced design centres for computers, tool rooms, information centres, etc. for the benefit of the industry. Specialised agencies such as National Small Industries Corporation (NSIC), Small Industries Development Centres (SIDC), have been particularly set-up for small industries. The financial institutions are also now actively supporting technical and technological efforts of enterprises and have even set up specialised organisations, such as, Technology Development & Information Company of India (TDICI) at Bangalore, and Risk Capital & Technology Finance Corporation (RCTFC) at New Delhi. Venture Capital Schemes and Companies have also come up in the recent past. Consultants play an important role in the acquisition, transfer and development of technology. The enterprise can identify competent consultancy organisations/consultants relevant to its areas of operations and develop necessary linkages with them by way of utilising their services in any area of interest. Consultancy services are generally effective and provide solutions to problems on case to case basis. Consultants can also help in developing linkages and utilisation of facilities available at national institutions or elsewhere.

Activity 3

Name three enterprises along with their major manufacturing activities/products, and indicate, with reasons, the types of linkages they should build-up with industry associations and name them.

Name of the Enterprise	Type of linkages	Name of Industry Association	Reasons

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12.7 LINKAGES

We have earlier seen in the preceding units that strong &T lastucture and institutional mechanisms have been built-up in the country, and the facilities and expertise available can be shared or taken advantage of by the industry or the enterprises. The linkages of these facilities at enterprise level is important and may lead to cost effective technology programmes, particularly in hi-tech areas. The large enterprises may have certain level of in-house R&D and other technological facilities and therefore need to have linkages with other institutions at a higher level or of specialised nature. The small enterprises are generally not able to afford to provide adequate funds for R&D and technological activities within the company, and, therefore, may need to depend even on expertise and facilities available in other institutions at a rather relatively low technology levels. Such requirements could include design engineering, product design, process modifications, quality control measures, cost reduction techniques, testing facilities and so on. Linkages are therefore important for all enterprises whether large, medium or small, with the institutional and other facilities available in the country, in the area of generation, development, and transfer of technology, for an effective management of technology

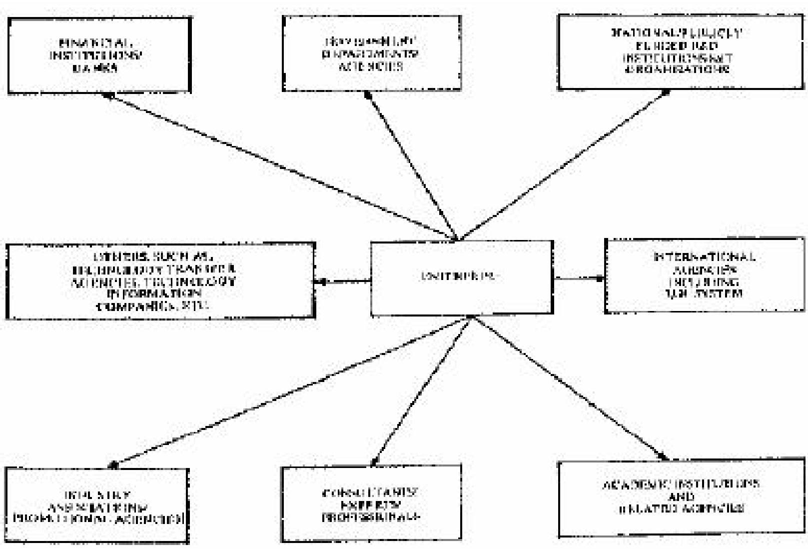

Figure 12.1: Technology Management Linkages at Enterprise Level

Activity 4

Identify, with reference to your organisation, various groups/agencies involved management of technology and analyse their roles and linkages. Have any suggestions to offer concerning linkages which would increase profitability of your organisation through technology management?

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Activity 5

How could your organisation be benefited by cultivating some linkages with national or international institutions in the matter of technology? Explore and discuss with the head of the Engineering or Technology Division of your organisation.

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12.8 SUMMARY

Technology Management at enterprise level involves several aspects and issues internal and external, and no enterprise can be fully self-dependent in the modern world of fast technological changes and economic re-adjustments taking place all over the world. Every enterprise, has to depend and take advantage of the national and international facilities and expertise available elsewhere. It is, therefore, important that necessary linkages are built-up and further developed wit h r relevant institutions and agencies dealing with various aspects of technology, particularly relating to its business environments. Such linkages are helpful in many ways, such as, timely availability of information, advanced equipments and testing, facilities, participation in skill development programmes, sources of technologies, and so on, These linkages may ultimately result in cost-effective and profit-oriented operations for the enterprise by exploiting appropriate technology management systems.

12.9 KEYWORDS

National Institutions: Publicly funded S&T Institutions and R&D Laboratories.

International Agencies: UN organisations and other bilaterally & multi-laterally funded organisations for promotion of mutual cooperation at international level.

International Cooperations: Cooperation at international level among various countries mainly in the area of science and technology or technology related activates.

Industry Associations: Associations set up and promoted by industrial groups mainly to promote their interests and interaction with the Government and other related agencies.

Linkages: Contacts and interactions with the relevant S&T and other related organisations concerning activities of the enterprise,

12.10 SELF- ASSESSMENT QUESTIONS

1) What is meant by "linkages"? Why are they necessary for an enterprise having Technology Management Group?

2) Write a note on national institutions in the area of Science and Technology. Critically review the role played by CSIR.

3) Enumerate international agencies engaged in the promotion of S&T cooperation among developed and developing countries.

4) Write a note on International Cooperation in Science and Technology. Has it really benefited the developing countries?

5) Discuss some useful activities of the industry associations and agencies for promotion of technology in India.

6) Briefly discuss the existing institutional facilities and mechanisms available in the country for possible linkages with regard to technology activities in your enterprise. How would you take advantage of such linkages?

7) Briefly explain International S&T Cooperation Programmes in India. How far, in your opinion,' they have been effective in strengthening national technological capabilities?

12.11 FURTHER READINGS

Status Report on Science & Technology in India: 1990, Council of Scientific & Industrial Research (CSIR), Rafi Marg, New Delhi, India.

Trade and Technology Directory of India: 1991, Vol. 1, Economy and Trade, New Delhi, India.

Journal of Development & South-South Cooperation, Dec., 1989 Development Experiences of Asia, Centre for International Cooperation and Development (CICD), Ljubljana, Yugostavia.

Yearbook of International Organisations, 1978, Union of International Associations, 1, rue aux Laines 1000 Brussels, Belgium.

United Nations, Industry 2000 - New Perspectives, 1979, UNIDO, Vienna

International Sub-eontrreting: 1978, A Tool of Technology Transfer, Asian Productivity Organisation, Tokyo

Appendix

S&T COLLABORATION AGREEMENTS

S. No	Country	Area of Collaboration
1.	Argentina	Agriculture, Biotechnology ,Water Resource Management and Non-Conventional Energy Sources,Agricultural Research & Education
2.	Australia	Numerical Models for Analysis and Prediction, Tropical Meteorology & Satellite Meteorology
3.	Bangladesh	Flood Control and River Development.
4.	Canada	Silvi-pastoral Research (phase-II) Fish Disease Bibliography Project, Research Projects on Alternate Feeding Schedules & Oyster
5.	People's Republic of China	Agriculture, Biotechnology, Medicine, Electronics, Radio Astronomy, Laser S&T and
6.	France	Agriculture and Rural Development, Exchange of Scientists & Students, Materials and Information, Supply of Equipment and Organisation of Workshops
7.	Federal Republic of Germany	.Catalysis, Biotechnology, Coal Technology, Building Materials and Metal Composites.

8.	Hungary	Electronic Materials, Biotechnology, Laser Optics , Ceramics, Industrial Aluminium, Catalysts , Neurosciences and Machine Tools,
9.	Indonesia	Food, Health and Housing, Human Resource Development for Agriculture and Water Resources, Environment and Land Water Reclamation, Biotechnology and Immunology.
10.	Italy	Energy and Agriculture.
11.	Mauritius	Radio Telescope.
12.	Nepal	Hydel Generation.
13.	Netherlands	Water Resources, Environment & Forestry, and Non-Conventional Sources of Energy,
14.	Nigeria	Pharmaceutical Research, Biotechnology, Solar Energy, Leather Industry, Micro-electronics and Computers.
15.	Pakistan	Clean Energy, Genetic Engineering and Biotechnology, Medicinal Research and Aromatic Plants, Renewable Sources of Energy; Environment and Meteorology.
16.	Poland	Coal Mining, Thermal Power Generators, Building Materials, Materials Science, Aeronautic Sciences, Fur Technology, Leather Technology, Instrumentation, Krill Fishing and Processing, and Biotechnology and Immunology.
17.	Sudan	Rapeseed/Mustard Cultivation, Remote Sensing Application.
18.	Switzerland	Biotechnology.
19.	USSR	Integrated Long-term Programme of Cooperation (ILTP) in areas-Building Materials, Powder Metallurgy, Joint manufacture and use of Electron Accelerators, Catalysts for conversion of Methane to Diesel Fractions, Fertilizer and Polymer.
20.	United Kingdom	Integrated Development of Western Ghats, Social Forestry, Paper Mills.
21.	USA	Water Resources.
22.	Socialist Republic of Vietnam	Seismic Survey in Offshore regions, Atomic Energy and Agricultural Research.

Uttar Pradesh
Rajarshi Tandon Open University

MBA-4.4
Technology Management

Block

5

TECHNOLOGY SUPPORT SYSTEMS

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LOCK 5 TECHNOLOGY SUPPORT SYSTEMS

u will recall that in the first block of this course we had introduced to you the ncepts, issues and implications of Technology. The second and third Blocks plained the core or key elements of Technology Management. While Blocks 2 and were more secular in character i.e. the principles underlying these topics are more less universally applicable, Block 4 was situation specific. The latter block cussed and examined the policies, instruments, mechanisms and incentives in ation to technology and the linkages that exist in this respect.

e present block, i.e. Block 5 deals with some support systems for technology anagement which must exist at the macro and micro levels if technology is to be anaged effectively.

is block has three units.

nit 13 deals with **Financing** of technology oriented projects. The institutional amework for providing finance for technology projects is described. The role of nture capital is particularly stressed. Various venture capital schemes are briefly scussed. The schemes available for financing upgradation of technology and for oviding assistance in the promotion of new enterprises, viz. consultancy services, trepreneurship development, etc. have been discussed. The role of capital market d the need for working capital have been examined. Finally, the importance of aluating R&D projects in terms of financial criteria is highlighted.

nit 14 **Information Systems** begins by underpinning the need for and importance of chnology information. It discusses the various types of information which are eded for harnessing and managing technology efficiently and effectively. The urces from where technology information can be obtained are described. The mensions of information systems services are presented. Finally, the benefits of chnology information systems are enumerated.

nit 15 deals with **Organising for Technology at the Enterprise level.** This is the last nit of the course and it attempts to encapsulate some of the main ideas of the rlier units. It looks more closely at some aspects of technology management. The eed for formulating a technology strategy and identification of technological gaps e highlighted. Evaluation of successful technology options and routes are amined. How to bring about technology transfer and successful absorption are plained. The need for instituting an effective monitoring system is stressed. The le of R&D and organising this activity as a vibrant component of the overall stem is analysed. The unit concludes with a brief discussion about the ways and eans of developing and training human resources for sustained development of chnology.

UNIT 13 FINANCING

Objectives

After reading this unit, you will be able to :

- acquaint yourself with the institutions engaged in providing finance for technology projects and[s] various services available to new entrepreneurs.
- know the various sources from where concessional finance for risky projects can be tapped and various services and infrastructure available.
- appreciate the need for evaluation of R&D projects.

Structure

13.1 INTRODUCTION

Finance is vital for setting up of any venture and more so for technology based firms which carry more risk. Such ventures need financing structures somewhat different from other ventures which are based on lower edge of technologies. Essentially, there are two types of financial considerations in a company-One relating to the funds for setting up a new unit or for diversification in an existing company involving purchase of plant & machinery, acquisition of technology, procurement of raw materials and components, etc. The other type of financial requirement relates to undertaking R&D activities and for building necessary R&D infrastructure. The funds in the first case often start yielding returns in a short period of a time (as was anticipated in the project or feasibility report of the project which might have been prepared). In the second case the returns start coming in after a relatively longer period and hence there is a greater uncertainty. However, it may be mentioned that some of the R&D projects relating to incremental developments/modifications may start giving returns in a short time, say, six months to two years. This type of R&D, though, is more common in India.

In this unit, we shall discuss the role played by development financing institutions in India and their schemes for financial assistance for technology based companies. We will also briefly discuss about the new avenues which have opend up over the recent past for technology oriented and risky projects.

13.2 DEVELOPMENT FINANCE INSTITUTIONS

Industrial projects cannot be financed entirely through the resources of the promoters. This is all the more true for technology based enterprises which are often promoted by first generation entrepreneurs or scientists having creditable technology experience and capabilities, besides commercial interest. In fact they need finance on more liberal terms because of higher risks involved. The development finance institutions realised this need and evolved special schemes and institutions for the purpose, To be able to successfully launch his project, the entrepreneur or his manager must be aware of the various schemes under which finance could be availed of. The present unit attempts to increase his awareness.

The institutions which are the main players in providing technology finance are :

- Industrial Finance Corporation of India (IFCI).
- Industrial Credit & Investment Corporation of India (ICICI).
- Industrial Development Bank of India (IDBI).
- Risk Capital & Technology Finance Corporation Ltd. (RCTC).
- Technology Development & Investment Company of India Ltd. (TDICI).
- Small Industries Development Bank of India (SIDBI).
- National Research Development Corporation of India (NRDC).
- Biotech Consortium India Ltd. (BCIL).

In addition, there are a number of venture capital fund companies both in the public and private sectors.

The development finance institutions (DFI) were set up with a view to provide finance for long term investment for industrial projects. As the country was trying to bridge the gap in its industrialisation vis-a-vis the developed countries, it had to encourage industries by providing concessional finance. For this purpose, the Government promoted the Industrial Finance Corporation of India (IFCI) in 1948, the Industrial Credit & Investment Corporation of India (ICICI) in 1956 and the Industrial Development Bank of India (1DB1) in 1964. The State Governments also prompted State Financial Corporations (SFCs) and State Industrial Development Corporations (SIDCs) for promoting industrialisation in their respective States.

The DFIs were primarily concerned with financing industries based on proven technology and for products with an existing market. Once R&D effort in the country bore fruit, this role was not enough. Stress had then to be placed on the transfer of technology from the laboratories to the manufacturing stage and utilisation of newer technologies. This called for flexible financial schemes, such as those provided by venture capital funds (VCF). All these financial institutions started venture capital schemes and set up venture capital fund companies recently.

13:3 VENTURE CAPITAL

One of the important inputs required in the transfer of technologies from the laboratory or conception stage to the manufacturing/commercial stage is the availability of **flexible financial assistance** or financial assistance that takes into account the risk factors.

Projects based on untried or relatively new technologies carry high risk as the returns are uncertain and the possibility of the technology being unsuccessful cannot be ruled out. Consequently, adequate financial assistance was not available from the conventional financing sources, which generally looked for projects based on tried and proven technolgies. While there is abundant availability of technical skills and expertise with research institutions, private organisations and individuals in the country, the entrepreneurs willing to take up the challenges and the risks involved in the commercialisation o(new technologies need the support of innovative financial institutions to translate their ideas. into reality. The need to fund such development-cum-commercial projects has led to the setting up of various agencies to provide venture capital mainly for the development of indigenous technologies.

Agencies for providing finance for technology development

In the budget for 1986-87, the Government of India decided to impose a 5% levy on all technology import payments, to create a fund to be operated by Industrial Development Bank of India, known as the Venture Capital Fund of IDBI. Since then, a number of specialised financial institutions have been promoted by the major all India Financial Institutions. The agencies providing assistance for such projects at present are the: Venture Capital Fund of IDBI, the Risk Capital & Technology Finance Corporation Ltd. (RCTC) promoted by IFCI, the Venture Capital Fund called VECAUS III promoted jointly by IFCI and UTI and the Technology Development and Investment Company of India Ltd. (TDICI), promoted jointly by ICICI and UTI. In addition, the following organisations have also entered into the field:

i) **SBI Capital Markets** the State Bank of India's Merchant Banking Subsidiary is setting up a venture capital fund. At present, this organisation provides finance to ventures through its bought out deals but the new fund will finance those ventures which have innovative characteristics.

ii) Grindlays Bank has launched the **India Investment Fund** with money raised abroad from non-resident Indians (NRIs) and is scouting around for projects which need venture finance.

iii) Canara Bank' has also set up a venture capital fund through its subsidiary **Canbank Financial Services.**

iv) **Credit Capital Finance Corporation** a private organisation has also launched a venture capital fund.

v) **Indus Venture Capital Fund** is another private sector VCF.

vi) Gujarat Industrial Investment Corporation (GIIC) and Andhra Pradesh Industrial Development Corporation (APIDC) have also promoted venture capital companies for operations within their States.

While the above organisations are yet to make a dent in the field, the organisations which have really gone ahead in their operations are RCTC, Venture Capital Fund of IDBI and TDICI as well as ICICI under its PACT (Programme for Advancement of Commercial Technology) Scheme. The basic features of these schemes are discussed in detail in the following paragraphs :

Scheme of Technology Finance and Development of RCTC

Risk Capital & Technology Finance Corporation Ltd. (RCTC), a public limited company incorporated with effect from 12th January, 1988 is the successor to the erstwhile Risk Capital Foundation (RCF), which had been sponsored by IFCI in 1975. It has been providing:

a) Risk capital to first generation entrepreneurs intending to set up industrial projects *in* the medium and medium large. sectors within a project cost range .of Rs. 2 crores to Rs. 10 crores, and

b) finance for technology development particularly for advancement of research and development.

It is significant that 60% of the cases assisted by RCTC involved technologies developed by the entrepreneurs themselves.

RCTC has been depending on funds support being provided by IFCI by way of subscription to its share capital and interest free loans. RCTC has so far given assistance in individual projects only up to Rs. .2 crores in view of its limited resources. To strengthen RCTC's resources to enable it to handle large number and larger size of projects as also to extend its ambit to cover a wide range of eligible , organisations, a venture capital fund has been floated by UTI and IFCI which would be managed by RCTC. The venture capital fund called "VECAUS III" has a capital base' of Rs. 30 crores.

The RCTC provides funds by way of **equity** participation which is treated as apart of promoters' contribution to share capital and also provides loans. Loans are of two types : **conventional and conditional.** As the interest on loans can cause a heavy burden do the **fledgling enterprise,** there is way to reduce this burden by giving a conditional loan. Conditional laons are interest free loans, which are to be serviced by profit sharing when the company earns profits. Even the conventional loans given by RCTC are concessional.'They are sanctioned at an initial interest, rate of 6% per annum to be stepped up gradually to 14% per annum. In suitable cases a moratorium on interest payment is granted.

The "VECAUS III" VCF promoted jointly by IFCI and UTI, and which is managed by RCTC, at New Delhi also provides finance through the above three modes viz., equity investment, conditional loan and conventional loan,

DSIR has also promoted a Consultancy Development Centre (CDC) at New Delhi, essentially with a view to promote and strengthen consultancy capabilities in India for domestic and export market. Also, efforts are being made to provide reliable services to small sector or new entrepreneurs at affordable costs. In the changed industrial environment the need for knowledge-based inputs is expected to increase considerably.

Venture Capital Fund of IDBI

The VCF of IDBI is designed to promote adoption of domestic technology and encourage the adaptation of imported technology. It covers the setting up of. pilot/demonstration plants, development of products or processes which substitute for imports or lead to quality upgradation, reduce material consumption, energy savings etc. It also covers the cost of surveys, seed marketing, market promotion and related training. The assistance is by way of conventional loans. The amount ranges between Rs. 5 lakhs to Rs. 250 lakhs for each project. The promoters are required to contribute 10% for projects costing up to Rs. 50 lakhs and 15% for ventures costing more than Rs. 50 lakhs. The assistance is available at a concessional rate of 6% p.a. during the development period which can be enhanced to 17% p.a. once the product/ process is developed and available to commence commercial production. The interest rate may be restricted to 14% p.a. with a charge on sales also.

Venture Capital Scheme of TDICI

After IFCI, ICICI is one of the first institutions in the country to initiate venture capital operations. The activity was commenced in 1986, and was later transferred by ICICI to a company created for the purpose called Technology Development & Investment Company of India (TDICI) at Bangalore. Under the scheme, TDICI extends financial assistance to projects involving commercialisation of new technology for which, due to inherent risk, the promoters may find it difficult to raise funds from traditional sources through conventional financial mechanisms.

Activities eligible

TDICI assistance is available to projects undertaking the following activities:

a) commercial R&D involving development of new technology or an innovative product;
b) implementation of an indigenously developed technology on a commercial scale; or
c) implementation of an innovative technology imported/transferred from an external source.

The new technology or the product concerned must have significant tangible benefits over the existing options and the financial return on the project should be commensurate with the risks. The assistance is available for projects having initial aggregate investment up to Rs.2 crores. The assistance is available in three forms i.e., conditional loans, conventional loans and equity investment. No specific promoters' contribution is stipulated.

Under its scheme, TDICI also provides assistance for projects which may not involve any indigenous technology development but are based on imported technology; it may be noted that VCF of IDBI and RCTC emphasise indigenous technology development.

PACT (Programme for Advancement of Commercial Technology) Scheme of ICICI

PACT scheme envisages technology development (and not technology transfer) through Indo-US joint ventures in R&D. It is expected that such joint ventures will result not only in development of new technologies, but also provide Indian partner an opportunity to acquire the R&D management techniques from USA. PACT co finance pre-production R&D costs of innovative products and processes.

To be eligible for PACT support, a project should

a) involve the development through R&D efforts, of an innovative product or process which promises tangible benefits to the Indian economy;
b) be proposed by an Indian company and US company as a team, with each member having a specified role in the development and commercialisation programmes;
c) have potential for commercialisation in three years;
d) involve project cost, typically not exceeding US $ 1 million and envisage a PACT contribution up to US $ 500,000;
e) involve technology development and not just technology transfer; and

f) not be related to defence/armament surveillence, weather modification or abortion-related equipment or services.

The cost of eligible projects should not exceed US $ 1 million and should envisage a PACT contribution up to US $ 500,000. The promoters' contribution is normally 50% of the cost of the project. The scheme is not a true Venture Capital Scheme.

Risk Finance by National Research Development Corporation (NRDC)

National Research Development Corporation (NRDC), New Delhi, a Government of India enterprise in the Department of Scientific and Industrial Research (DSIR), is charged with the objective of commercialising research carried out in national laboratories. It provides risk finance for technology development both by way of equity participation in companies set up for the first commercialisation of NRDC know-how and also provides development loans for setting up of pilot plants. NRDC's participation in equity capital is limited to companies set up specifically for commercialising NRDC know-how, having total capital investment of the order of Rs. 50 lakhs or more, restricted to the first commercial plant based on the technology given by NRDC. NRDC is prepared to share in risks by writing off a part or the whole of the development loan if the project is unsuccessful. NRDC acquires technologies from indigenous sources including national relations for transfer to companies as a package.

Fund Support by Biotech Consortium India Ltd. (BCIL)

The Financial Institutions have promoted a company called BCIL to provide financial assistance for preparation of Pre-Feasibility Reports (PFRs) and Detailed Project Reports (DPRs) for biotechnology based industries. BCIL, which was incorporated on the 14th September, 1990 with its Headquarters at New Delhi, has an authorised capital of Rs. 10 crores subscribed by IDBI, IFCI, ICICI, UTI and. RCTC, BCIL will catalyse preparation of reports on technology being developed by academic and research institutions as well as by entrepreneurs and industry with a view to minimise risks. Assistance will be available for financing fixed assets and operations. A minimum promoter's contribution of 10% for ventures costing up to Rs. 1 lakh and 30% for those above this has been proposed. It would also fund the preparation and completion of DPRs and the promoter's contribution would be in the range of 30 to 50% of the cost. In the case of pre-feasibility reports, the loan would be interest-free or at a lower rate to be converted into equity if the project moves to the DPR stage. In the case of DPRs, concessional rate of interest would be 6% per annum during the development period to be increased to 18% depending upon the estimate of the likely cash generation. If the project proves to be commercially successful, BCIL would expect returns in the form of royalty from the commercially successful projects but will not claim ownership of know-how or any patents. Equity investment will be in the form of direct subscription in the sponsored company. There would be suitable buy-back arrangements to enable the promoters to buy back these equity shares.

13.4 TECHNOLOGY UPGRADATION

No enterprise can remain competitive if it does not upgrade its technology from time to time. This can be achieved by in-house R&D, induction of newer technology and capital equipment from abroad or from indigenous sources. With a view to induct the latest technology in selected capital goods manufacture and meeting the need for indigenous Research and Development (R&D) facilities and reducing costs, special programmes of technology upgradation have been launched by the Financial Institutions. Assistance under the Scheme covers acquisition for upgradation of fixed assets including plant and equipment, know-how, drawings and designs and need-based margin, money for additional working capital needs of the proposed projects. Effective from 1st August, 1990, the loans under the Scheme carry concessional rate of interest of 11.5% per annum under Tier-I (up to completion period or 2 years whichever is earlier) and 12.5% per annum under Tier-II on the first Rs. 5 crores and on 50% of the loans above Rs. 5 crores subject to a ceiling of Rs. 7.50 crores per project for the concessional portion. The balance loan carries the normal lending rate of interest with additional interest of 1% per annum in case of closely held companies.

IDBI provides direct loans to industrial units to enable them to utilise the import licence under the Technical Development Fund Scheme of the Government of India. Generally the limit for assistance under the Scheme is Rs. 125 lakhs per undertaking per year. The Scheme covers all industries as also import of inputs needed by industrial units for improving export capabilities. Assistance under the Scheme is available only to existing industrial concerns with good record of performance and sound financial position. The applicant unit must hold an import licence granted by the Government of India under the Technical Development Fund and should also satisfy IDBI that the proposed imports will improve its productivity, exports etc.

13.5 PROMOTIONAL ACTIVITIES

Many new entrepreneurs, particularly those with a technical-academic background, find the move to industrial environment quite daunting. The procedures and channels of operation are often totally unfamiliar. Further, they are generally not in a position to pay for the high profile consultants.

Technical Consultancy Organisations

With a view to providing low cost but quality consultancy service to tiny, small and medium scale entrepreneurs, the all-India Financial Institutions, in collaboration with the State-level institutions and banks, have set up Technical Consultancy Organisations (TCOs), with the primary objectives of-

- providing under one roof the total package of services which include preparation of feasibility reports, project reports, carrying out market surveys and pre-investment ingentigations for prospective entrepreneurs,
- providing guidance to entrepreneurs on project development, implementation and operation as also technical guidance to the existing industrial units with regard to their schemes of diversification, modernisation and More efficient operations, providing marketing, financing and technical advice regarding rehabilitation of sick units,
- identifying potential entrepreneurs and undertaking activities relating to the development of the entrepreneur including training and providing technical and other assistance often free of charge.

At present 18 TCOs-9 under the lead of IDBI, 5 under the lead of IFCI, 3 under the lead of ICICI and one sponsored by Government of Karnataka-are providing a wide spectrum of consultancy and extension services to enterprises particularly in the rural, tiny, small and medium scale industrial sectors. A list of TCOs is given in Appendix I. DSIR has also promoted a Consultancy Development Centre (CDC) at New Delhi, essentially with a view to promote and strengthen consultancy capabilities in India for domestic and export market. Also, efforts are being made to provide reliable services to. small sector or new entrepreneurs at affordable costs. In the changed industrial environment the need for knowledge based inputs is expected to increase considerably.

Entrepreneurship Development Programmes on Science and Technology

The Science and Technology Entrepreneurship Development Programmes sponsored by the National Science & Technology Entrepreneurship Development Board (NSTEDB) are being funded partly by the Department of Science & Technology of the Government of India and partly by the all-India Financial Institutions, viz., IDBI, IFCI, ICICI etc. So far, the aforesaid institutions have supported about 300 Science & Technology (S&T) EDPs where about 6000 S&T entrepreneurs have been trained.

Establishment of Science and Technology Entrepreneurs' Parks

Science & Technology Entrepreneurs' Parks (STEPs) provide an interface between science and technology institute of excellence and industries, promote and nurture applied research and translate it into product development. It is an effort to channalise research excellence into business. The concept of STEP envisages promotion of industrial ventures by scientists and teahnogists by fostering a research-industry culture, near a research institute, which can help in the removal of technical difficulties in the commercialisation of new technologies.

Under the auspices of NSTEDB, STEPs are being set up on the lines of Science Parks in USA and UK. Eight such STEPs have already been agreed to be supported by, all-India financial Institutions at: (i) Ranchi (Bihar), sponsored by the Bihar Institute of Technology (BIT), (ii) Tarapur (Maharashtra), sponsored by the Jawaharlal Nehru Engineering Chemical Park (JNECP), (iii) Tiruchirapalli (Tamil Nadu), sponsored by the Regional Engineering College (REC), (iv) Kanpur (Uttar Pradesh), sponsored by Harcourt Butler Technological Institute (HBTI), (v) Mysore (Karnataka), sponsored by Sri Jayachamarajendra College of Engineering (SJCE), Ludhiana (Punjab), sponsored by Guru Nanak Engineering College (GNEC), Bhopal (Madhya Pradesh), sponsored by Maulana Azad College of Technology (MACT), and (viii) Kharagpur (West Bengal), sponsored by Indian Institute of Technology, Kharagpur. DST is the modal agency for this activity. Recently, Technology parts are also being established to provide infrastructural facilities and support to innovative companies.

Promotion and support to consultancy services

As mentioned earlier, the Department of Scientific & Industrial Research (DSIR), Government of India, has set up a Consultancy Development Centre (CDC) with the support and cooperation of various consultancy organisations and associations. The CDC promotes and supports consultancy organisations with a view to meeting the growing need for and importance of development of consultancy profession in India. This is an important development because it can play a major role in acquisition, upgradation, transfer and export of technology and services. The primary objective of CDC is to encourage and support technological activities including the collection and dissemination of information/data of consultancy organisations. A Consultancy Development Assistance Scheme, among others, has also been initiated mainly to encourage and recognise performance and activities of consultancy organisations.

Technology Business Incubator (TBI)

Small businesses have the maximum difficulty in obtaining infrastructural services such as land, telephones, facsimile machines (fax), computers, management consultants etc. The Technology Business Incubator (TBI) is like a large workshop, which provides space facilities and environment for starting business. The TBI has all the service facilities required by any business and is managed by an experienced manager, who can advise the new entrepreneur regarding the difficulties that he may be facing. Once the business is put on a commercially profitable footing, which may be in about three years, it is required to vacate the premises, and make way for another new entrepreneur. Maharashtra Industrial and Technical Consultancy Organisation (MITCON), in Pune, has been identified among others, to start a general TBI in Pune. This TBI will accommodate manufacturing and service enterprises. The other proposed sites for TBIs include Central Electronics Engineering Research Institute (CEERI) Pilani and Shri Ram Institute for Industrial Research at New Delhi. This TBI programme of CSIR has been started for the first time in India and only three sites have been related on experimental basis. Efforts are on to promote many more TBIs in India; the number may touch even a few hundreds during the Eighth Plan period.

Activity 1

i) Why do the development finance institutions provide free training courses for entrepreneurship development? Discuss.

ii) List out the four most important areas of work of technical consultancy organisations.

iii) How are STEPS and TBIs useful for new entrepreneurs?

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13.6 CAPITAL MARKETS

In the early days of industrialisation, businessmen had to depend upon loans from the development finance Institutions for raising the finances required because the financial sector was not developed enough. The banking system was not as extensive systemsas it is now arid the stock exchanges were yet to gain importance.

However, in the 1980s, the equity cult took off, and investors including household savers, are keen to invest directly in the equity of companies. This trend has been further encouraged by the **Mutual Funds,** which have taken over the role of managing the **Investment portfolio** for the small investor. This has reduced their risk and the transaction cost of operating in the stock markets. Many commercial banks and finance companies have also started offering similar services to small investors.

However, the small businesses still do not have access to the stock exchange because there is a minimum value limit for the issuing of equity to the public. This barrier has also been removed in 1990 by the creation of the Over-The-Counter-Exchange (OTCE) for trading in the scrips (equity share certificates) of small companies, which are not listed on the stock exchanges.

As equity capital imposes no immediate cost towards its servicing, the small businesses can now have access to this source with greater ease. This will help reduce their debt service cost and improve their profitability. They may not be able immediately to get these resources directly, but may be able to get them through the venture capital fund companies. The VCF companies can issue their shares to the public and use the resources to finance more new technology companies. The public at large is conscious of the nature, level and source of technology used by a company while offering its shares in the market, and in fact, many companies do mention the level and source of technologies in their announcements.

13.7 WORKING CAPITAL

Considerable effort is often put in preparing feasibility reports. Great care is also taken in assessing the technology, the market, the raw material availability and even the quality of the personnel. The capital cost of the project and its financing is also done with meticulous care. However, when it comes to assessing the requirement for working capital the same care is often not shown.

Working capital is a very important element in the success or otherwise of an enterprise. Owing to delays in project implementation and cost over-runs, a majority of projects run into liquidity problems. Such shortages of money at critical stages can lead to severe difficulties, and have even been known to lead to the project being abandoned. It is, therefore, advisable to provide liberally for working capital.

Factoring

Small businesses, which do not have a large complement of staff, have often faced difficulty in collection of their dues from their clients. The bigger clients even use their greater strength to delay payment to small suppliers. This puts an unbearable strain on the latter's resources.

To help them get over this problem, bunks have started factoring services. In factoring, the bank takes over the responsibility to collect the money due on unpaid bills. The bills usually of small concerns, are taken at a discounted (lower) value. The task of the collection of the money against the bill is thus taken over by the bank and the businessman gets immediate payment. The uses of factoring services have to pay some nominal charges.

The working capital needs of small businesses can be greatly reduced by using the factoring services. In their absence, large amounts of money used to remain locked up in unpaid bills, and the businessman was forced to borrow further money to continue production. Now he can get immediate payment and devote himself to his primary task of running his business efficiently.

13.8 FINANCIAL EVALUATION AND CRITERIA FOR EVALUATING R&D PROJECTS

The financial institutions and commercial banks are expected to evaluate the project proposals received from companies for financing for economic and technical viability and to ensure that they would be able to get back their money. Most of these institutions and banks have developed in-house expertise to appraise the projects and sometimes seek export and advice from outside also, if necessary. However, it is felt in business circles that projects are not adequately appraised from technology point of view. The financial institutions and banks also generally do not have adequate built-in technical capabilities particularly in the context of fast changes taking place in technologies and managerial systems. The result is that the industrial sickness is increasing alarmingly and large funds have been locked up with sick units. In view of this, it is necessary that the personnel concerned with the technical appraisal of the projects are adequately trained and exposed to the newer developments and trends.

It should be seen, rather insisted, that project reports are prepared by really competent professionals and consultants. The role of chartered accountants and others should be limited to their fields of activities, and not allowed to cover technological issues unless such capabilities have been demonstrated. The viability of a project largely depends upon the depth and care with which the project report has been prepared, appraised and implemented. A sound approach on the part of the financial institutions and banks would go a long way in proper utilisation of scarce funds and would ensure reasonably good returns on investments made.

Scientists and R&D personnel in a company are not able to fully appreciate the commercial aspects and the need for financial returns from their R&D projects. Time targets are often slipped. It is therefore necessary that Technology Management group carefully examines the financial inputs required and expected financial gains from a particular R&D project. In any corporate research laboratory with good management and talented researches, there will usually be more ideas for projects than there will be funds and personnel; to act on all of them. Accordingly it is an important management function to select research projects that would turn into innovation. The selection of research projects should be based on both technical and financial criteria (Betz, Frederick, Managing Technology Prentice-Hall, New Jersey, 1982). It would be pertinent to ask-

i) Is the project technically feasible and exciting in creating new functionality or advancing technical performance?
ii) Will the project contribute significantly to corporate profitability.

The expenditure on Research and Development is a capital investment which yields returns or enhances profitability in the future. Like a*y new investment, the principal management criterion for evaluating R&D projects are cash flows and return on investment, which have been traditionally used to evaluate new products. For a successful R&D project, sales will eventually grow until either (i) the market is saturated (ii) competition limits market share for the product, or (iii) product obsolescence occurs. It is necessary that R&D personnel are made adequately aware of the above.

As we have studied earlier, the objectives of R&D projects can be classified as-

i) Supporting current businesses
ii) Creating new ventures
iii) Exploring new technologies

Financial evaluation of projects may use the following approaches for different purposes:

Current businesses

- The current products are projected as to life times
- The product mix is then projected as a sum of projects
- Contribution to extending the life times or improving the sales *or lowering* costs of products is estimated

New Ventura

- Projects that result in new ventures are chartered over expected life times
- Cast flow requirements and return on investment are calculated

Research

- These projects are not financially evaluated but chosen for their potential for dramatic impact on technological performance.
- Project costs are treated as an overhead function in corporate R&D.

Activity 2

Clive an example of an R&D project ,in ,a company, that you may be aware of with respect to its financial benefits or otherwise, as ,may be evaluated at the end of the project.

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Activity 3

Has your organisation sought any financial assistance for technology-based and risky project? If: yes, describe the project.

i) Why do you regard the project risky? Enumerate the reasons.

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ii) Describe the salient features of the agreement under which finance was available.

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iii) Offer 'your comments on the project:. and financial assistance :made available.

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13.9 SUMMARY

Promoters are not able to provide all the finance required for setting up industrial projects and, therefore, raising finance from other sources is necessary. The Development Finance Institutions (DFIs) mainly provide loans, while venture capital funds provide mainly equity or conditional loans (which are in the nature of quasi-equity). The DFIs have set up technical consultancy organisations (TCOs) to provide facilities like preparation of feasibility reports, market surveys, guidance to entrepreneurs, training in entrepreneurship etc. Entrepreneurs can obtain some of those services free of charge and other at concessional rates.

The capital markets are now well developed and so the present generation of businessmen need not entirely depend upon DFIs for term loans. Earlier small businesses could not make public issue of equity because of minimum value limits. Now with the starting of Over-The-Counter-Exchanges (OTCE), trading of shares of companies not listed on the stock exchanges can also take place.

Financing a business does not end with only tying up the resources required for setting up plant and buildings. Working capital is equally important and needs to be provided for liberally. This will minimise liquidity problems which almost all start-up businesses have to face

Cash Flow and Return on Investment methods are used to evaluate R&D projects. R&D personnel need to be adequately aware of financial implications of the investments in R&D and this is an important management function at corporate level.

The capability or expertise for project appraisal by financial institutions needs to be suitably augmented. Such institutions and commercial banks need to follow more professional approach in order to reduce the incidence of industrial sickness.

13.10 KEY WORDS

Development Finance Institutions : Financial Institutions. (Fls) which provide long-term finance for capital investments, e.g. IFCI, ICIC1, IDBI.

Venture Capital : Investment finance, usually in the form of share capital, provided 'by venture capital fund companies to innovative projects, involving high risk and expected high returns.

Conventional loans : A loan carrying a fixed rate of interest and repayable over a pre-determirled period.

Conditional loan: An interest-free loan to be serviced through profits when they arise. It need not have a fixed ending period.

Mutual Funds: Funds raised through shares for participation in schemes for the purchase of shares of companies and other securities. The funds are managed by professional managers. As the investments are in a large number of companies, the risks are spread and, consequently, minimised.

Factoring : Services provided by Factoring Organisations (started by banks in India) for talking on the responsibility of collection of unpaid bills of business concerns. A discounted (lower) value of the bill is paid immediately by the factor. Factors may also provide the facility of maintaining the receivables account on behalf of the concern. At present only banks have been permitted to start factoring services in India.

R&D evaluation: Financial evaluation of R&D projects by a company.

Technology Business Incubator: A facility promoted by DSIR to nurture small and technology based business.

S&T Parks: S&T entrepreneurs encouraged and supported through S&T parks, by DST.

13.11 SELF ASSESSMENT QUESTIONS

1) What is the role of the development finance institutions in providing funds for project financing?

2) Which institutions should the promoter of a new project approach for raising loans and which for raising share capital?

3) i) Name four Venture Capital Funds.

   ii) What are the forms of financing adopted by Venture Capital Funds?

4) What are the guidelines for funding from TDICI and RCTC? Briefly discuss the PACT of TDICI.

5) What kind of investment activity is financed by IDBI under its technology finance schemes?

6) i) What is the main difference between a Stock Exchange and an Over-The-Counter Exchange?

   ii) In what ways is equity capital better than loans for project financing.

7) i) Why is the proper estimation of working capital important for the success of a business?

   ii) What is factoring? How does it help small businesses?

   iii) What are the criteria for evaluation of R&D projects in a company?

8) What services are provided by the technical consultancy organisations? From where do they get their resources?

9) What facilities are available for new technology projects? Can risky projects/products get cheap finance?

10) A small businessman has to spend his time chasing trade debtors. What facilities are available to him to avoid this?

11) What are the recent initiatives of the Government to encourage (i) small and - technology based entrepreneurs; and (ii) large technology based companies?

12) "The financial institutions and banks need to be more innovative and professional in appraising/evaluating the project proposals technologically to reduce industrial sickness." Comment.

13.12 FURTHER READINGS

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APPENDIX 1

Name of Technical Consultancy Organisations
SPONSORED BY IDBI

1) Kerala Industrial & Technical Consultancy Organisation Ltd. COCHIN-632016

2) North Eastern Industrial Technical Consultancy Organisation Ltd. GUWAHATI-781021

3) Bihar Industrial and Technical Consultancy Organisation Ltd. PATNA-800061

4) U.P. Industrial Consultants Ltd. KANPUR-208 002

5) Andhra Pradesh Industrial and Technical Consultancy Organisation Ltd. HYDERABAD-500029

6) Orissa Industrial and Technical Consultancy Organisation Ltd. BHUBANESWAR-751 007

7) J&K Industrial and Technical Consultancy Organisation Ltd. JAMMU-8) 180001

8) West Bengal Consultancy Organisation Ltd. CALCUTTA-700007

9) North Eastern Industrial Consultants Ltd. 1MPHAL-795 001

SPONSORED BY IFCI

1) Himachal Consultancy Organisation Ltd. SHIMLA-171001

2) Rajasthan Consultancy Organisation Ltd. JAIPUR-301001

3) Madhya Pradesh Consultancy Organisation Ltd. CALCUTTA-700 071

4) North India Technical Consultancy Organisation Ltd. CHANDIGARH-160017

5) Haryana Delhi Industrial Consultants Ltd. SONEPAT-131001

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1) Gujarat Industrial & Technical Consultancy Organisation Ltd. AHMEDABAD-380009

2) Industrial & Technical Consultancy Organisation Ltd. MADRAS-600 006

3) Maharashtra Industrial and Technical Consultancy Organisation Ltd. P U N E -411005

UNIT 14 INFORMATION SYSTEMS

Objectives

- After reading this unit you will be able to
- Appreciate what is technology information and what is its importance.
- Understand the main contents of technology information that are required while establishing and operating a modern industrial organisation.
- Identify main sources from where information on technology could be obtained.
- Understand the process of establishing a Technology Information Service and the benefits that can be obtained from the availability of technological information at the corporate level.

Structure

14.1 INTRODUCTION

Technological developments in the last 4 to 5 decades have been so rapid that they have made visible impact on the life styles of mankind all over the world. The technological changes, have, in fact, been at an exponential rate. The advent of new and emerging technologies have added momentum to the process of change. In the years ahead, technology is going to play a very major role an the industrial and socio-economic growth of any country. This also would have an important bearing on the corporate performance. Growth and profitability of an organisation will not, only depend on-resource availability and its optimum utilisation but also on the technological content of its products and services. A survey of 700 companies in the USA has indicated that technological content accounted for 1/ 3rd of their profit in the decade of '80s as compared to 1/5th in the previous decade. The next decade' may perhaps take it to 1/2. In other words, changes in technologies cannot be ignored or given a secondary place.

In today's world, no industry can remain isolated or indifferent to what is happening around. Development in certain areas, particularly in the information and communication technology, have widened the range of operations of a technology developed in one place covering the rest of the world. In view of this, it has become all the more necessary to take advantage of the developments elsewhere. It is abundantly clear that in the years ahead, it is 'technology' that will shape our lives and technology will indeed be our only ally.

But to make the optimum use of technology, various types of information relating to technology become a prerequisite. The generation of technologies today is so rapid that a point has been reached where being informed of a particular technology is as important as the technology itself.

14.2 WHAT IS TECHNOLOGY INFORMATION?

Technology information in simple terms means information on technology. This brings up two questions. What is "information" and-what is "technology". While there is no official definition of information, it is referred to as a communication of facts, findings, results, ideas and thoughts. The technology essentially means "know-how" that is, ways of designing, manufacturing or utilising things, It can also be defined as the know-how to transform concepts into goods and services for the satisfaction of customers. It is a broad form of resource endowment-an embodiment of knowledge for production of goods and services. Technology is imbibed in various forms, the most common of this could be identified in the machines used for manufacture or the skills that are transformed through human beings. These forms would comprise know-how, know-why, technological processes, designs, drawings, specifications, computer programmes and other information, besides industrial training, industrial property rights etc.

The importance of technological information as a key element in the development, process in a country has been well acknowledged. Whether the issues relate to investment, technology acquisition, manpower development, research and development, the information is an important prerequisite for a sound decision. In the process of establishment of a new undertaking or during its operation, information is one of the first requirements and the success of subsequent operations largely depends on the quality of information on which the initial decisions were based. Therefore, a sound information base is a sine quo non for healthy industrial and technological growth.

There is a difference between information on science and information on technology. Let us make this difference clear. Science investigates, in a systematic way, the nature and behaviour of the natural and physical universe. Its objective is to attain new knowledge from such an investigation. Technology, on the other hand, is not interested in the knowledge per-se but is concerned with the application of such knowledge in the context of trade and industry. Therefore, information on technology would be concerned with items such as equipment, process of manufacture, input-output norms, application areas, pollution control aspects, sources of technology, terms of transfer, size of production, input requirements such as raw materials, capital, energy and others.

14.3 WHY TECHNOLOGY INFORMATION?

Why is information on technology so important? There are many reasons and a few important ones are:

i) When an entrepreneur decides to set up a manufacturing unit, he wants information on sources from where he could get technology. This he needs so as to make an optimal choice out of available technologies that he can use in the manufacturing process.

ii) The information on plant and equipment required, the raw materials needed, the energy requirements, the pollution control aspects, its appropriateness to local conditions are all very important parameters which could not possibly be ignored.

iii) The investigator would like to know, for instance, how contemporary is the technology that he is proposing to acquire? What is the technology growth in that industry? Haw soon it would be outdated and new and more efficient technologies would overtake his product? For all this the investor would need information on patents, technology life cycles, research areas and others.

iv) When deciding to install a new manufacturing technology, the investors would like to ensure optimum output with the desire& quality and in competitive conditions. There have been a number of cases of failures due to wrong choice of technology. Therefore, a variety of. information on technology would be required to guard against such failures.

There are many such other items of information on technology which are vital for the success of a manufacturing enterprise.

14.4 CONTENTS OF TECHNOLOGY INFORMATION

The technology information would usually cover technological aspects of products, process equipment and technical services. It covers both hardware and software aspects. While it is not possible for us to provide a complete inventory of items that should be included, it suffice to say that all such information which is desirable for the activities of a modern industry would be covered. If the set of information is arranged according to the phases of preparation and implementation of a project, the following key information would be required. It may be noted that the listing is only illustrative, and not comprehensive.

Pre-feasibility state

- Alternative products with their technology content
- The stage at which the products are in their technology life cycle
- Sources of availability of technology
- Plant and equipment required
- Optimum size of plant
- Raw materials, utilities and manpower requirement
- Status of process and design development
- Status of industrial property rights
- Appropriateness of technology under local conditions
- Possibilities of sources of funding for technology

Feasibility Stage

The above set of information but in greater detail and with greater depth and scope is required. For instance, regarding sources of technology one would seek information on the various sources of supply of technology, their relative merits and demerits and cost of technology. This information indeed is very desirable so as to be in a better bargaining portion while acquiring technology. Looking at the vast number of technologies that are coming out every year and at the information explosion, a point is being reached where knowing about the information on technology is becoming as important as the technology itself. Aspects like input-output norms, technology services and assistance to be provided by the technology licensor, terms of transfer etc. would be needed. Similarly more details would be required on the impact of technology on environment. What pollution control measures would be required? What are the safety aspects involved?

Implementation Stage

- Information on plant installation and operations
- Training particularly in any specialised skills that may be required
- Machinery maintenance schedules
- Technology absorption and adaptation plans

Plant Operation Stage

- Product quality and quality control measures
- Efficiency of operations-
- Product application, potential fields of new applications
- Technology absorption and adaptation
- Alternate, raw materials and components
- Product upgradation in terms of design, manufacturing techniques and operation
- Technology forecasting
- Reduction in cost of operation due to technology ugradation

Once it is broadly known as to what information is required, the question is from where to obtain the same.

14.5 SOURCES OF TECHNOLOGY INFORMATION

Technology information abounds. Product brochures and techno-economic feasibility studies needed by firms and entrepreneurs are just as plentiful as the thousands of commercial technologies available. The volume of information for researchers is even more staggering. In 1970,there were almost 2 million papers on science and technology and the number jumped to 6 million by 1980. Between 1965 and 1975, chemical abstracts increased from 34,926 to 201,663, physical abstracts went up from 34,000 to 87,636, and electrical and electronics abstracts doubled from 119,500 to 244,975. The United States alone produces some 400,000 articles and 15,000 books on science and technology every year. The rate of increase is so much that papers on science and technology are expected to double every 10 years. Thus such a vast amount and source of information is available!

Just as a good technology does not automatically reach an entrepreneur who could make full use of it, a good technology information does not automatically reach the person who needs it. There is always the possibility of an entrepreneur accidentally passing by a trade fair or meeting a technology agent and thus be exposed to the technology in the same way that many technology information users come across information through friends or in magazines. Leaving the exposure to technology information through random chance, however, is not the best way of bringing 'technology to the user. Not only would opportunities be lost but the exposure might be biased towards technologies with good advertisements but which may not necessarily be appropriate for The firm or the country.

It is, therefore, necessary that thereis a systematic approach to acquiring information The main task would be tapping the right source while there are a large number of sources from where information could be obtained, a few important ones are:

- Published literature
- Exhibitions and Conferences
- Industrial and Trade Associations
- Government organisations and departments Patents
- Experts and Consultants
- Data banks/bases

Published Literature

Published literature are available in the form of technical text books, manuals, encyclopedias and periodicals which are useful for references on technology aspects of a product and process. There are also many directories dealing with various issues ranging from products, processes, manufacturers, traders, exporters, corporation, experts and R&D institutions. They are reference tools for a quick scan of technologies and their sources. Some directories even provide preliminary screening of dependable companies.The exporters directory, for example, could identify manufacturers who, by virtue of being exporters, might be more reliable in terms of quality control and of meeting deadlines.

There are also technical literature and directories published by international organisations such as UNIDO, ILO and others.

Then there are magazines from where considerable information can be obtained. While there are certain magazines which are specially devoted to technology aspects, there are others of general interest which devote a section or column to technology.

Exhibitions and Conferences

Exhibitions and conferences are also extremely good source of technology information. The current trend is that there are special exhibitions devoted to technology. The products and the technical descriptions are on display, giving a quick view of the technology. There are also seminars on new trends to update the audience on the new technologies. Meeting rooms are also provided to enable sources and potential users to come together to discuss possible technology transfer. A large number of exhibitions and conferences are held in India by several organisations in various technological and related fields. Trade Fair Authority of India (TFAI) is the focal agency for trade fairs/exhibitions/buyer-seller meets in India and abroad.

Industry and Trade Associations

The industry and trade associations regularly publish directories and year books which also have information on technology. The news letters provide information of technology trends, policies and products and processes..

Government Organisations

These are also extremely important and useful sources of information. For instance the Department of Scientific & Industrial Research brings out technology status studies on a wide variety of subjects. These provide useful information on current status of technology, the future trend, sources of technology and many other such information. The DGTD is also a good source of information on specific technologies. Similarly there are other organisations like the Department of Electronics, Department of Environment, India Investment Centre, etc.

Patents

This is a rich source of information. A look into this can uncover inventions, including those not protected by the national patent law. It identifies which countries and companies are dominant in particular technologies. It gives an update on the state-of-the-art of patent based technologies that could guide firms and entrepreneurs as to where their business concerns could lead as well as encourage innovators to stimulate their creativeness or to rekindle old ideas.

The information on patents in India could be obtained from the patent offices located at Calcutta, Delhi, Bombay, Madras and the centralised information centre at Nagpur.

Experts and Consultants

When one is in difficulty in understanding technical details, in finding the source of information or in solving a technical problem, one may resort to the use of technical consultants. Technical consultants could provide from "band-aid" to "major surgery" assistance.

The list of consultants is available from various sources such as the Consultancy Development Centre, National Association of Consulting Engineers, Association of Consulting Engineers and others. The list is arranged subject wise.

In case of the required expertise is not available locally, one could approach foreign consultants.

Data Banks/Bases

These are one of the most important sources of information. These are store houses of information on a vide variety of subjects. Their main objective is to provide the relevant information from a number of sources that are available today. The data bases have developed very rapidly with the advancement in electronics and communication field. Everyday, a large volume of information is being generated in different forms, all over the world. It is difficult physically, for any individual. or single organisation to keep track and store all such information. The development in computers and communications has made it possible.. In fact a large number of data bases provide information all over the world. The on-line retrieval has made it possible to get the desired information in a matter of few minutes, if not seconds.

In connection with this source of information, one normally comes across two terms Data banks and Data bases. It is necessary to understand the difference between the two, The data banks contain information which can be directly used, for example, information which is of a statistical or financial nature or which provides lists of products or names or addresses of companies etc. Data bases, on the other hand, contain bibliographical information with abstracts and indexing and refer to original documents which may be journal articles, books, reports, conference papers and others. These are also, at times, referred to as textual data bases. Most data bases have their roots in printed indexes and abstract journals and are the computes ed version of abstract journals. Full text data bases which contain full texts and documents are also now in operation.

A wide variety of subjects are covered. A few typical examples are:

- patents

the local information centers for ensuring resource sharing activities like inter-library Information Systems loans, referal services and document supply services. A software research centre called National Resource Software Centre (NRSC) has been established recently at Vishakhapatnam. The centre will acquire information handling software packages from international and national organisations, among its other activities.

NISSAT has also taken up the establishment of on-line search facilities on a permanent basis in the country and Five Regional Access Centres have been established: INSDOC at Delhi, National Chemical Laboratory at Pune, National Aeronautical Laboratory at Bangalore, Central Leather Research Institute Madras, and Indian Association for Cultivation of Science at Calcutta. Library Networking has also been planned., by NISSAT to ensure better utilisation of S&T information resources through resource sharing moderate functional load of information. centre management and to take care of motivational factors to a large extent by better means of communication. In the first phase. the libraries are being networked at Calcutta and Delhi.

Technology Information, Forecasting and Assessment Council (TIFAC)

As a follow up of Technology Policy Statement (1983), TIFAC was set up under DST as an autonomous body in February 1988 with the following objectives:

a) Creation of an information system including data base/data bank

b) Conducting action oriented studies and forecasting in selected priority areas

c) Action towards publications and creation of Public Information System Base

d) Management development

e) Creation of TIFA machanisms in Ministries/Departments and develop necessary linkages as a system; and

f) Development of linkages with private sector, small industries and educational sector.

TIFAC has initiated actions to collect, analyse and disseminate technological and related information, in terms of preparation of technical 'reports, setting up of information links with the help of NIC and other agencies.

National Informatics Centre (NIC)

National Informatics Centre (NIC) in the Planning Commission is now providing computer based information services to the Central and State Government departments, and district administration in the country. A computer communication network called NICNET has beep established connecting the districts, central and state government departments for quick information flow through satellite. The four super computers installed at Delhi, Bhubaneshwar, Pune and Hyderabad form four regional centre nodes of the network. The NIC state centres set up in the state capitals have super-mini computers (ND-550 or equivalent while the districts have AT computers with four terminals. Major network services available on NICNET include Electronic and distributed .Data Base. Special projects of NIC include Tele - informatics Development Programme, Computer Aided Design Programme, General Information Service Terminal (GIST), conducting training programmes, etc.

Foreign Data Banks/Bases

There area number of data banks/bases operating abroad. 'A number of them are very large in size. For instance, one of the systems contains more than 175 million records, These range from a directory type listing of companies, abstracts of a. journal, to the complete text of a statement, latest development trends. in plastics and others.

A few examples are

International Organisations (UNIDO, ILO, EEC)	UNIDO's Industrial & Technological Information Bank (INTIB) Industrial enquiry services Industrial development abstract

3)	Central Machine Tools Institute (CMTI) (NICMAP)	Statistical data base	Import and export statistics of machine tools covering Indian and some leading countries
4)		Census data base	Census of machine tools and allied equipment installed in Indian industries
5)	"	Machining data base	Information to help the process engineer to optimise the cutting conditions
6)	"	Bibliographic data base	Periodical articles, books reports on machine tools
7)	National Instt. of Science, Technology and development Studies (NISTADS)	CLOSS (Current data base Literature on Science of Science)	Covers Indian literature on S&T policy studies including foundation aspects S&T resources and practices, implementation and monitoring aspects
8)	"	Science & Technology archivals	Covers Science policy literature appearing in Indian journals, by Indians in foreign journals and foreigners in India
9)	National Instt. of Oceanography (NIO), Goa	Oceanline data base	Bibliographic data
10)	National Aeronautical Laboratory (NAL), Bangalore	CD ROM information centre	Information on hardware and their suppliers relating to aeronautical requirements
11)	Central Glass and Ceramic Research Institute (CGCRI), Calcutta		Abstracting and bibliographic information on Glass and Ceramics
12)	Indian National Scientific & Documentation Centre (INSDOC)	Abstracts	Abstracts of Scientific literature published in Indian journals, Conference proceedings, their reports, patents and standards
13)	INSDOC	National Union Catalogue of Scientific Serials in India (NUCSSI)	Holding of various journals and periodicals on science subjects received by various libraries in India
14)	"	ENVIS	Compilation of non-governmental organisation activities in the field of environment
15)	National Information System S&T (NISSAT)	SCI (Science Citation Index)	Citation details covering 18 Indian periodicals
16)	"		Testing facilities in India
17)	Technology Information Forcasting & Assessment Council	TIFACLINE	Information on technology related subjects
18)	National Information Centre (NIC)		Information needs of Govt. Departments and Organisations.
19)	Department of Science & Technology (DST)	TIPS (Technological Information Pilot System)	Information on selected sector of Industry regarding business opportunities, covering offers of goods, services, technologies etc. from ten developing countries.
20)	Patent Information Centre, Nagpur		Covers Patents registered in India

21)	TDICI, Bangalore	Technology information	Information on technologies and funding for development in India
22)	Asian and Pacific Centre for Transfer of Technology (APCTT), Bangalore	Information centre	Information on available technologies in ESCAP region

To illustrate, we give below brief particulars about some of the important data bases.

National Information System for Science & Technology (NISSAT)

The need for a National Information System for Science & Technology (NISSAT) was visualised in a report prepared, at the instance of Government of India, by an UNESCO consultant Dr. Peter Lazer in 1972. The high powered National Committee on Science & Technology (NCST), constituted by the Government for preparing a comprehensive S&T plan, which was to become an integral part of the Fifth Plan, recommended in 1973 the establishment of NISSAT under the then Department of Science & Technology (DST). However, since 1985 NISSAT has been under the Department of Scientific and Industrial Research (DSIR). NISSAT has the following objectives:

i. Provision of national information services to meet the present and future needs of generators, processors, disseminators and users of information;

ii. Optimum utilisation of existing information services and systems, and the development of new areas;

iii. Promotion of national and international cooperation and liason for exchange of information;

iv. Support and active encouragement for the development of facilities for education and training in information science and technology, and in the communication of the national science information policy;

v. Support and participate in research, development, and innovation in information science and communications to enhance both the efficiency of information services and quality of the information provided by these services, and

vi. Support and promote research, development and innovation in information technology. NISSAT has established nine sectoral information centres with the objective of creating information awareness and meeting the information needs of academicians, scientists, technologists, entrepreneurs, management executives and decision makers in specific sectors. The details of these centres are given in Table 14.2.

Table 14.2: Sectoral Information Centres under NISSAT

	Sectoral Centre on	Located at
i)	Leather Technology	Central Leather Research Institute, Madras
ii)	Food Technology	Central Food Technological Research Institute, Mysore
iii)	Machine Tools	Central Machine Tools, Bangalore
iv)	Drugs and Pharmaceuticals	Central Drugs Research Institute, Lucknow
v)	Textiles and Allied subjects	Ahmedabad Textile Industry & Research Association, Ahmedabad
vi)	Chemical & Allied Industries	National Chemical Laboratory, Poona
vii)	Bibliometrics	Indian National Science Documentation Centre, New Delhi
viii)	Advanced Ceramics	Central Glass and Ceramic Research Institute, Calcutta
ix)	Compact-Disk	National Aeronautical Laboratory, Bangalore

The sectoral centres were built around the existing information resources and facilities. The services provided by these centres include document, supply, preparation of special bibliography, patent search, reprography and micrograp industrial enquiry and translation services. These centres also act as focal point of

- material sciences
- Engineering
- Electronics
- Telecommunication • Chemical engineering
- Energy
- Pollution control technology

and many more.

The data banks/bases operate at different levels. At the unit level, the purpose is basically to meet the needs of the organisation itself. At the national/sectoral level, it is intended for the entire industry or other users. At the international level, they serve the users in various countries. Satellite communication has made the on-line linkage easier and faster.

The on-line information system is now a big industry in Europe, USA and other advanced countries. The entire system follows a chain:

i) The producers of data bases and data banks
ii) The distributors or vendors generally called hosts
iii) The telecommunication services
iv) The end users or brokers who search data files on behalf of end users.

Producers of on-line information can be commercial, academic or trade organisations. They process a mass of original documents or primary literature by scanning, classifying, indexing, abstracting, formatting, etc. to create data files which

The host organisations are information service centres for the dissemination of information on-line. They load and update several data files, on their computers and these are accessible to the users through the hosts own information retrieval software. For example, a host offers on-line access to 130 data bases/data banks which could be searched with one command language. The information retrieval language varies from host to host. The host organisations tend to specialise in different information areas, for example, scientific and technical information, business, industry, technology, etc. and compete with each other.

The on-line information user is linked to the host computer via a telecommunications link. Each host has a `Network User Address' (NUA) which allows the users to specify to the network which host they wish to be connected to. Each user needs a Network User Identifier' (NUI) which is the network subscribers identification number and is obtained from the national Post and Telegraph Terminals (PTT).

The potential user of on-line information needs certain equipment like a modern, a software package, a telephone and a password. He can then have access to the data bank/base. There are also brokers who search data files/information on behalf of the end users.

14.6 DATA BANKS/BASES IN INDIA AND ABROAD

There are various data banks/ bases operating in India and abroad. .
A list of few data banks /bases operating in India is given in Table 14.1

Table 14.1 : List of Data Banks/Bases in India

Sl. No.	Name of the Organisation	Name of the data base	Details of the data base
1)	Dept. of Mines (in collaboration with NIC and Indian Bureau of Mines)	National Mineral data base	Information on Mineral deposits in India.
2)	Central Machine Tool Institute 20CMTI) (NICMAP)	Product data base for Machine Tools and allied equipment	Information regarding product group, product name, type, model features price, manufacturer's name etc. of machine tools

	LINK (Information generated outside UNIDO) TIES (on Technology Transfer agreements) INPRIS (UNIDO project details) EIS (UNIDO energy activities) Statistics
USA & European databases	A large number of databases on a variety of subjects Bibliographic references Patents Abstracts Grey literature Trade & Co. directories Statistics
USSR	International Centre for Scientific and Technical Information (1CST1)
Japan (ACST)	Scientific & Technology Information,
S. Korea (KIST)	Science & Technology Information.

14.7 DIMENSIONS OF TECHNOLOGY INFORMATION SERVICES

The importance of technology information to corporate management and for national development has been well recognised. Particularly medium and large scale units should have their own technology information service. Similarly at the regional and national level there should be need for suitable technology information service. The exposure to technology information to a seeker should not be through random chance but should be systematic and reach the right user at the right time, at the right price and in the right `arm. This should indeed be the objective of a technology information service.

There are two important aspects in a technology information service:

i. Processing of Technology information
ii. Packaging of Technology information

These are described briefly as under:

Processing of Technology

The processing of information is mainly concerned with organising material for current and future use. The material or documents which contain the information have to be suitably organised in such a fashion that not only the document but also the information contained therein could be retrieved quickly. In fact,, there are two dimensions of technology information processing, one relates. to the physical entity and the other relates to the information content. The Library Science provides various methods of handling most types of documents containing the information, As regards content of information, assistance may be required from subject specialists.

Packaging of Information

Packaging of information refers to making the message or content of the information to the needs of the user. The effort is to give "right information in the right format. The packaging of technology information proceeds from a clear understanding of the needs and wants of the users of. information. It should be appealing to the users. As an old saying goes the bait must be appealing to the fish, not to the fisherman.

It is not uncommon that technologies are presented from the point of view of the source-i.e., an inventor or researcher, using technical jargon that could be understood only by scientists and researchers but not by the target clients. For instance, if they were to write about a new stove, they may highlight that the stove saves 15% on energy and hence, in the name of energy conservation, they would then ask the housewife to use it. Mentioning 15% savings and appealing to patriotism may not have the desired impact. But if the message they convey is that the woodstove costs only Rs. 250, is efficient, smokeless and convenient, uses agricultural residues and saves Rs. 5,000 on fuel per year, then they can get the attention. This is what is involved in packaging.

The basic steps involved in packaging is first to know the product, i.e., its content and its unique features. Second, is to identify the target clients. Third, we have to isolate the selling points of the products which appeal to the target clients in terms of meeting their needs and wants. Fourth, we have to select the language and style that is understood best by the target clients. Fifth, we have to decide on the media mix that could deliver the message well.

14.8 BENEFITS OF TECHNOLOGY INFORMATION SYSTEM

Any activity costs money and must yield profits. Collection and use of information need certain infrastructure and investments. An efficient technology information facility at corporate level usually reduces technology acquisition/development cycle and hence costs. It thus makes the company more competitive, particularly in rapidly changing areas such as electronics, telecommunications, computers, biotechnology, materials, etc. The experience all over the world is that investments in an efficient and dynamic information system with proper linkages yield manyfold returns over a period of time. The hardware of information system facilities may range from a simple Personal Computer (PC) to satellite based large computer systems incorporating a variety of peripherals and devices. For example, a simple PC for analysing the R&D data or for collection and storage of information relating to technologies, equipments, materials, quality control and standards, etc. may be adequate for a small company having limited in-house R&D objectives. But for a large corporation which has a large R&D budget or for a software exporting company which has a satellite based information system (particularly for linkages with their customers and counterparts abroad), software (hardware and application oriented) capabilities and related knowledge are important for efficient utilisation of information systems.

Information Technology itself has developed into a discipline and there have been rapid advancements in the hardware and software techniques, a variety of configurations being available to the user. An efficient information system for introduction of new technologies and products in the market and their sources, availability of materials to reduce inventory periods, and so on may be found highly beneficial from the viewpoints of competitiveness and, improving profitability.

Activity 1

Analyse in respect of your organisation the type of information you would need and the sources from where you would obtain the same?

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Activity 2

Design a technology Information Service for your organisation.

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14.9 SUMMARY

Technology plays a major role in the industrial and socio-economic growth of any country. In the changing scenario with rapid developments in the field of communication, information on technology has become a prerequisite for successful operation of an industrial organisation. One must be able to identify the areas on which information would. be required for the establishment and operation of the unit. Since technology information abounds, it is desirable to identify suitable sources so that the desired information is available at the required time, in the appropriate form and at the optimal cost. Large number of data banks/bases that. exist today are one of the major sources of such information. The objectives and facilities of some of the technology data such as National Information System for, S&T (NISS'T); Technology Information, Assessment and Forecasting Council (TIFAC); and National Informatics Centre (NIC) were discussed. Finally, benefits of an information system in a company were mentioned. An efficient information system with necessary hardware and software facilities is becoming a necessity to maintain competetiveness and improving profitability in the fastly changing environment.

14.10 KEY WORDS

Technology Information: Information in the form of facts, findings, results, ideas, 'thoughts, know-how and know-why related to technology.

Data Banks/Bases : Store houses of information (raw or processed data) on a wide variety of subjects. The main objective being to provide relevant information from all possible sources.

Online Information System : Information readily available on demand through . computerised systems. Commercial online information systems are available in the market today to meet a variety of requirements.

National Information System for Science & Technology'(NISSAT) : An establishment set up by DS1R to provide technical/technology information/data bases mainly through sectoral information centres at different places in the country. It also provides training and other services to the industry and other S&T agencies.

Technology; Information, Forecasting and Assessment Council (TIFAC) : An autonomous body under DST for promoting and supporting TIFA activities for industry and other organisations.

National Informatics Centre (NIC) : A computer based information centre, under Planning Commission, to provide services to the central and state government departments and district administration in the country. It has taken several initiatives to provide and encourage use of information services in new areas.

14.11 SELF ASSESSMENT QUESTIONS

1. What do you understand by Technology Information? What is the difference between information on science and information on technology?
2. Why is the need for technology information felt in a company? Illustrate through an example.
3. What are the contents of technology information at various stages of setting up an enterprise? Give an example.
4. What are the normal sources of technology information? Discuss relative merits of any two information on sources.
5. What are the main data banks/information systems, established in India? Which ones are the most useful to your organisation and why?
6. "In today's world, no industry can remain isolated or indifferent to what is, happening around"? Comment.

7. What is technology information? What are its main contents?
8. What do you think would be the consequences if appropriate technology information is not available?
9. "There are too many technology information systems/data banks agencies in.the country but none of them has been really very effective as far as industry is concerned. Perhaps an "Information Agency" is required to collect and collate information about the existing data bases and supply the same to industry." Comment.
10. Write exhaustive notes on
    a) NISSAT
    b) TIFAC
    c) NIC
11) What benefits would accrue to a firm/industry if it has a well developed technology information system?

14.12 FURTHER READINGS

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UNIT 15 ORGANISING FOR TECHNOLOGY AT ENTERPRISE LEVEL

Objectives

After reading this unit you will be able to understand (with. special reference to an enterprise) the:

- meaning and significance of Technology Strategy in an enterprise
- concepts of technology adaptation, implementation and upgradation
- choice of technology and its impact on enterprise
- possible strategies in the areas of Finance, HRD and Market Development in relation to technology management
- research and development (R&D) strategies
- need for monitoring of technology.

Structure

15.1 INTRODUCTION

In the earlier units we studied the various concepts, issues, facets, tools and techniques relating to technology management. It is now time to recapitulate and have a closer look on all these various aspects, particularly: from the point of view of an industrial enterprise. We shall do this in an integrated manner keeping in mind the national environment, policies and infrastructure. Any attempts aimed at recapituation or reinforcement usually calls for certain' amount of reiteration of earlier material/points. Hence, some repetition is inevitable. Though the subject has been discussed at a general level, real life examples have been drawn with experiential insights from the cement industry in India.

15.2 TECHNOLOGY STRATEGY FOR THE ENTERPRISE

Organising technology at the enterprise level is part of corporate planning function and is a continuous process. This can be. divided into the following three streams :

- Replacement of obsolete technologies with newer ones; and continuous modernisation of existing technologies for improving productivity and competitiveness.

- Development and introduction of new products with a view to Diversify.
- Setting up of new units.

While having certain common components, the above three streams have certain operational differences and, therefore, need to be dealt with separately. However, the first step to technology planning for any of the streams is the defining of the technology status and the forecasting of technology needs, keeping in view the technology trends (domestic and global) and to the changing market in order to better satisfy the consumer expectations. While defining strategy, the time frame of technology cycle and its impact needs the maximum attention. Further, technology should be identified not only in term of machines but also products and processes to achieve the desired end product and level of productivity. This can be clarified by comparing core industries like Cement and Steel with fast track Electronics industry. While in the first case changes in the machines and processes take place without consumer getting the feel of it, in case of electronics and consumer products, the product range changes have an impact on consumer because he gets involved in it.

Further, a company engaged in the manufacture of consumer electronic products has very little time at its disposal to bridge the gap and keep pace with changes, but a company making cement or steel could go in a systematic manner to improve its state of technology and simultaneousley meet the requirements of employment policies and marketing distribution system in the country in order to satisfy the consumer needs effectively.

The questions of technological obsolescence, time cycle and scale of operations are more relevant today than they were ever before. It is because of the increased pace of technological developments, emerging intense competition and stepping in of electronics in almost all industries-be it automobile, telecommunication, aviation, cement or mineral industries where use of micro-processor has now become more a necessity than fashion-that the concepts of scale or size of production have assumed increasing importance. India is passing through transition phase where we have technologies varying from bullock cart to A-320 aircraft. Appropriate technology for each industrial segment is thus the need of the hour and should be the objective of an enterprise. While we might like to introduce bio-engineering, super conductivity and jet engines in one go, the scale of operations and results achieved may or may not justify the same. Since technology strategy of the corporation has a long term impact, its appropriate choice in the context of the operating environment is very critical.

As indicated earlier, the technology strategy of an electronic consumer product company, for instance, cannot be the same as that of Steel, Cement or other core industry. And within the same sector, the technology strategy of a company will change depending upon whether its target is domestic, international or mixed market. For example, the technology strategy of a 100% Export Oriented Unit (EOU) company has to be the state-of-the art technology and also has to be backed up by the capability to quickly (or fastly) respond to the changes in accordance with the merging global situation. On the other hand, the strategy of a core industry company will be governed by domestic needs and Government's socio-economic policies.

Technological changes at the enterprise level should take cognisance of the following:

a) Country's changing economic scenario

b) Changing cultural and living standards

c) Government policies including those with respect to import and export and their effect on cost.

d) Global changes taking place in the range of products affecting the economic scene and living standards

e) Intensity in competition

f) Economics and sociology of conservation (e.g. energy conservation, conservation of inputs like minerals etc.) and pollution control consciousness created as a result of Government policies and pressures.

Some of the typical products exemplifying the global or universal trends are the TV, Video, automotive and home appliances industries in which a sort of explosion inat Enterprise Level demand has taken place.

In these very industries, greater computerisation, control through remote instruments (i.e. remote control) and miniaturisation are the technological changes which are now taking place.

15.3 TECHNOLOGY GAPS AND ENTERPRISE NEEDS.

After the internal resources, customer needs; global technology and market trends have been evaluated, the next step is to precisely identify the gaps at the enterprise level. While quantitative methods can assist in the identification of emerging technologies and possible know-how gaps, an assessment based on the following can be of direct use for an existing set up (for new enterprises the more scientific methods may be necessary):

- Feedback data on the performance of existing equipment and failure analysis report, comparing productivity, cost of production and quality vis-a-vis acceptable standards.
- Feedback data on basic product parameters vis-a-vis other competitors and keeping watch on their plans and activities.
- Technology scanning by product groups.
- Interaction with customers, foreign companies, consultancy organisations, institutions, etc.
- Mapping the international technological status through tendering, obtaining quotations, engaging foreign consultants and evaluating the same in terms of domestic/export environment for the enterprise.
- Clearly defining the technology life cycle of new products as a consequence of technological changes by means of cost benefit analysis and with reference to time frame for implementation.
- Energy conservation and pollution control policies and strategies.

The management of technology at the enterprise level requires that the technology management group should receive necessary inputs for formulation of possible technology options from the customers, business groups and other corporate agencies. Based on these inputs the Technology Management Group should identify gaps in technology and formulate possible new technology alternatives. Thus the specifications of the required new technology get firmed up as a first step. The plan of action to implement the strategy may include:

a) Resource analysis of the company in terms of availability of technological expertise, finances, skills and equipment.

b) Analysis of Customer (both current as also emerging) needs and the time frame of validity.

c) Analyse the global data regarding the state of art of the technology and the markets. Based on these inputs, the Technology Group carries out an evaluation of available options and the cost benefit analysis to arrive at investment decision.

d) Identify the route: technology acquisition vs. in-house development.

Activity 1

Choose any high-tech industry, within the core sector. Ideatifu the gaps in technology and. suggest some ways to bridge the gap and also prep [re] a time table for bridging the: gap.

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15.4 EVALUATION OF TECHNOLOGY OPTIONS AND ROUTES

Evaluation of technology should be based on the enterprise needs. The latter are based on several factors, as we mentioned earlier, such as study of the market and existing and global state of the art of the technology. The right selection of a forecasting method in relation to technology need is important. Needless to say, the most important aspect of any evaluation is the corporate objectives of the enterprise. Although technology forecasting is considered to be a highly riskly venture, yet due to the fact that technologies are based on science and innovations, it should not be difficult to determine as to when the current technology will reach its physical limits keeping in view the status of upgradation process. Technology evaluation process on the other hand is becoming more complex because the finer analytical techniques used in evaluation generally require large amount of data on technology related factors e.g., technological obsolescence rates in the past, upgradation trends for key features, scale of operations, efficiency and reliability factors, rate of developments regarding use of inputs and materials, venture capital financing, volume to success ratio, energy and pollution considerations, etc. All such data may not be available at a single place or may not be easily accessible to the enterprise. Various sources have to be tapped to collect such data which, even if possible, requires substantial amount of time and cost. The identification of suitable sources for both data and its interpretation are important. The services of a professional agency may thus be felt rather necessary. Once the decision about the technology route has been arrived at, the various technological options offered have to be evaluated strictly in terms of the parameters of the enterprise strategy.

The technology evaluation has following three critical parameters.

a) Resource analysis by the Enterprise
b) Techno-commercial considerations of customer
c) Techno-commercial considerations of the enterprise

The technology proposed to be acquired from outside may be examined with respect to the following:

- Adaptability and reliability of operation and maintenance of the proposed product/process/equipment in Indian conditions.
- Suitability of indigenous raw materials and other local endowments for the technology.
- Major technical features/parameters of the product/process such as performance/efficiency/productivity, inputs like power consumption, fuel consumption, etc.
- Performance and reliability indicators of the products/process,
- Phased manufacturing programme, if relevant (under the new industrial policy this requirement however is no longer Valid)
- Govt. guidelines for import of technology
- Upgradation guidelines and the costs involved
- Participation by foreign collaborator
- Competitiveness and reputation of the licensor's products in the Indian and world markets together with market share and backup services
- Willingness on the part of the collaborator to assist the licencee in attending the site problems, removing generic defects in the equipment and debugging other operational problems
- Capability with regard to other product ranges, types, models, etc. not covered, in the original agreement,
- Possibilities of engineering. and other back-up support within the country and potential for indigenisation as fast as possible,
- Cost analysis for enterprise and its comparison with global and domestic competition,

- Availability/development of skills Organising For Technology
- Easy availability of spare parts/solution to maintenance problems in the country, at Enterprise level including standard bought-outs,
- Long term (5 to 10 years) cost analysis and its relevance to the consumer,
- Adaptability to the existing set up (techno-commercial and cultural),
- Time frame for technology absorption and upgradation
- Technology transfer costs such as lumpsum payment, royalty, etc.
- Detailed erection/commissioning instructions,
- Supply of manuals (regarding operation, quality and maintenance),
- Training details of personnel at all levels at the site and at licencer's unit and costs for the same,
- Supply of detailed specifications, information and drawings, wherever necessary,
- Performance guarantee for the product when manufactured at the licencee's works without any strings.

After evaluating technology proposals of different suppliers or parties on the basis of above, considerations, it is essential to clarify the scope of technology transfer to as great an extent as possible.

Development of Technology is quite expensive, both in terms of time and money. An individual enterprise generally may not be able to affort this luxury unless the size of the enterprise is large or on a global scale. Special inputs are required to transfer technology from laboratory to market. In case of limited resources, what an enterprise should do is to study the differences in raw materials, machines and processes and highlight the same to seller or developer of technology and work for their adaptation and optimisation for the enterprise.

Government of India has been changing its trade and industrial policies from time to time; the latest changes relate to the creation of market economy. With freedom allowed to foreign companies to own 51% equity, and even upto 100% in select sectors, and import of technical know-how, the procedural situation is considerably changed, and so have the technology strategies to change.

In view of the policy environment it may be almost impossible to meet the technology needs of an enterprise facing competition, more so in high-tech areas, through in-house R&D efforts alone because of limited resources and capabilities compared to most of the foreign companies in industrial countries. Therefore, a definite role has to be identified by a company for its in-house R&D. In the light of this, therefore, it has to be decided what appropriate technology package should be purchased taking into account market needs and resources. This is highly subjective as in different countries the economy levels are different. For faster growth the path of acquisition of technology is thus considered necessary by many enterprises. It is now more relevant than even before due to the new policy of the Government to permit outside investment which in turn would perhaps bring the latest technology also. Once a state of art technology is imported it is necessary to continue to upgrade and modify the same so as to avoid or minimise further imports and face international competition in select areas.

15.5 TECHNOLOGY TRANSFER AND ABSORPTION

The technology transfer plan and absorption, to a large extent, depend upon the mode of technology transfer which in turn depends upon the scope and specific needs of the enterprise. For example, technology transfer needs and mechanisms for setting up a new plant, and those for improving the productivity or introducing new products in the existing plant would be different. The normal modes of transfer are: Turnkey joint ventures, technical know-how licencing, one time purchase, vetting, modernisation through Technology Development Fund (TDF) schemes and purchase of prototypes and drawings.

Once the negotiations with seller/collaborator have been completed and taken on record, it is essential that the licencee should evolve a proper back up organisation

ensure smooth technology transfer for both design and manufacturing. The R&D set up should also be activated to support the technology transfer process and develop the know-why capabilities. A time bound project plan and implementation scheme after conclusion of the collaboration agreement as also a comprehensive technology transfer plan have to be prepared defining the responsibilities of the various divisions of the company. Coordinated by the Technology Management Group, the project plan could cover several aspects, e.g., receipt of technical documentation, training of licensee personnel at the collaborator's works, establishment of any additional manufacturing facilities, production build up and achievement of indigenisation levels. A system for continuous monitoring of technology transfer plan at the product, divisional and corporate levels has to be developed depending upon the area/ scope of collaboration. The indigenisation scheme and training of engineers in identified areas at the colloborator's works after familiarising them, with the documentation received from the collaborators has to be worked out so that the trainees could derive the maximum benefit from their stay at the collaborator's works. The involvement of R&D is necessary to carry out product improvement research so that the technology acquired is upscaled and improved upon after successful absorption. Cement industry has done exceedingly well in the absorption of technology imported from different sources. Some highlights of this experience and the benefits accrued therefore are given in Appendix 1. The following guidelines need to be followed for transfer and absorption of imported technology:

i. Continuous monitoring of technology transfer plan at the product, divisional and corporate levels.

ii. Training of engineers in identified areas at the collaborator's works after familiarising them with the documentation received from the collaborator, so. that they could derive the maximum benefits from their stay at the collaborator's works.

iii. Analysis of documentation, technical information etc. received from the colloborators by the R&D groups and preparation of specific developmental plans for import substitution, product improvement, cost reduction, etc. keeping in view the innovations taking place internationally.

iv. Entrusting the R&D group with the responsibility to carry out product improvement research so that the technology acquired is upscaled and improved upon further.,

v. Associate the Technology Management Group from the initial stages of technology transfer plans including negotiations, training, discussions, etc. held with the foreign collaborator.

The above strategies should help the organisation to absorb/adapt imported technology and achieve self-reliance at the earliest, thereby avoiding further imports of technology.

Activity 2

Identify companies in the industrial and service sectors where acquisition of a particular technology has been managed well.

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Activity 3

a) Identify a couple of Lc_lhnologies acquired by your organisation through collaborative tie-ups.

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b) Familiarise yourself with the contents. of these collaboration agreements and analyse/write down some notable details regarding the agreements and comment upon them.

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15.6 R&D ORGANISATION AND ITS ROLE

The R&D set up of the company has to be geared up to assimilate imported technology, if required even at short notice. They should also lay down criteria for evaluation of technology and technology transfer mechanisms and identify areas for training. Large number of collaboration agreements are executed every year involving various modes of technology transfer. The collaborations in high tech areas are more common in Indian organisations. The role of foreign collaborations in Indian industry has been very prominent both in private and public sectors. More than 75%c, of electronic items, 70% of agricultural machinery, 65%₀ of transport machinery and 35% of all drugs made in the country are products of foreign collaboration. The R&D set up technology management group of the organisation should be used to maximise benefits of technology. They should develop the following capabilities:

i. Capability to solve generic problems, overcome product deficiencies by in-house efforts.

ii. Ability to design and develop variants, upgrade the product or system to suit the changed operational requirements.

iii. Assimilation and adoption of quality control procedures for manufacture at works and arrange bought-out items for erection and commissioning indigenously to the maximum possible extent.

iv. Ability to bridge the gap between the technology received and likely to be available over the next five to ten year period, without taking recourse to technology imports.

v. Confidence level in the company for handling the product independently after expiry of the collaboration agreement.

vi. A regular communication channel between the two parties (supplier and receiver of technology) at different levels may be established. This can be achieved through annual or bi-annual reviews and frequent feeedback to the licencer from the licence on the market situation and the performance of the product.

vii. The technology management group, including the R&D personnel, should ensure appropriate linkages with the support infrastructure and policy inplementation agencies, including financial institutions, for necessary facilities and information required during the technology development/technology transfer stages. The possible grants and incentives, besides recognition of the in-house R&D unit by DSIR, should be availed of to the minimum possible extent,. especially for high risk projects.

15.7 MONITORING THE TECHNOLOGY TRANSFER PROCESS

A company has to keep abreast of the changing environment of business both at domestic and international levels. The major changes which need monitoring at the organisation level are market trends, technological upgradation and "state of art[6] R&D. The monitoring assumes a greater significance because of free market concepts being introduced now. Another imported aspect which the enterprise has to keep in view is the fastly changing scenario in India. The pace of change in technology will be much faster now than noticed in the earliest decades.

An on-line system for monitoring technology changes and a system for evaluation of their relevance and impact on the organisation have therefore to be given the foremost place in the organisation's corporate planning process.

The above discussion is also relevant for a new organisation, as it is for an existing set-up, except that it does not have previous experience and built-up technological capabilities, and hence has to generally acquire technological from elsewhere on perhaps lesser favourable terms. Any enterprise-new or existing, besides keeping track of the changes, has to keep itself in readiness to implement the changes at the fastest speed and thus keep its resources, such as funds, men and material always in readiness.

While an enterprise, on one hand, may establish its own R&D facilities and keep up the upgrading of the facilities, on the other, its process of technology evaluation has to be active all the time in order to remain competitive.

An enterprise must have a system of forecasting technological changes with time schedule and organise the human resource (HR) structure in a manner that all unit operations, individually and collectively, are optimal.

15.8 RESOURCE MANAGEMENT

The four major resources required for acquiring and managing the technology are the finance, human resources, raw materials and infrastructure. A thorough examination and evaluation of these is necessary. The evaluation criteria for raw materials and infrastructure being similar to those in other projects, the human resources have to be attended to from the initial stage through proper training. The financial resources have to follow the Government guidelines and corporate policies, more so for foreign investment or expenditure. There have been specific Government guidelines in regard to the quantum of payments to foreign collaborators, including the maximum rates of royalty and even the methods c[al] calculation of turnover to pay royalty. Government guidelines also exist in other areas like subcontracting and sub-licensing rights, export rights, patents and brand names etc. These have to be scrupulously followed as the collaboration agreements require Government approval. Till mid 1991, many procedural steps had. to be completed before the actual signing of the collaboration agreement. These norms and procedures have been modified recently to avoid procedural delays, unnecessary restrictions, etc. Earlier the participation of collaborators and setting up of ventures by outside companies was restricted up to 40% equity participation. The same has now been modified to 51%. Another significant step is abolition of licensing in most of the areas and import of goods and services against exitn-scrips which can be sold by an enterprise. This is likely to cut down the time and expenditure and encourage participation by foreign companies who can now transfer larger component of profits and reinvest the same. 100% export oriented units (EOUs) will have altogether different norms. Once the tie-up has been made with the supplier, the decision to fund the scheme through internal resources, public funds or loans (domestic or international has to be taken and finances organised, both for foreign exchange and rupee components.

The recent liberalisation of policies for foreign investment and collaborations are likely to reduce the irritants. With restrictions and procedural requirements being gradually relaxed, a time may come when such constraints may practically cease to exist.

15.9 DEVELOPMENT AND TRAINING OF HUMAN RESOURCES

The major objective of a technology organisation, whether for a new unit or an existing one, is to achieve the highest productivity and quality in order to maintain competitive edge. The main instrument to achieve the objective is development and training of human resources. The spectacular achievement of Japan, Germany, Brazil and Korea can be attributed to upgrading of Human Resources (HR) through training and development which became the focal points in their technology management efforts, The HRD efforts enabled these nations and their enterprises to achieve significant progress in much shorter span of time.

Striving a balance between technology development and development of human resources is the most important task of the enterprise in view of the time gap that usually occurs between technology development and HR development. While technologies change fast, human resource do not develop that fast. It has been observed that most industrial units do not plan or provide for HR component to cope with modern man-machine system. The technology may be there but qualified and skilled manpower to operate the technology may not be available within the enterprise. Poor start-ups, long gestation period and inability of certain enterprises to achieve the expected productivity levels may partly be due to this gap and also due to the lack of systems perspective in which numerous elements are required to be planned and developed to match the technical elements. This is true for Indian enterprise in different industrial sector-be it Electronics (fast track) or Cement and Steel (conventional). It is well recognised now that behaviour and attitudinal changes at all levels of organisation are essential through systematic approach for realisation of full benefits. This is portrayed in Figure 15.1.

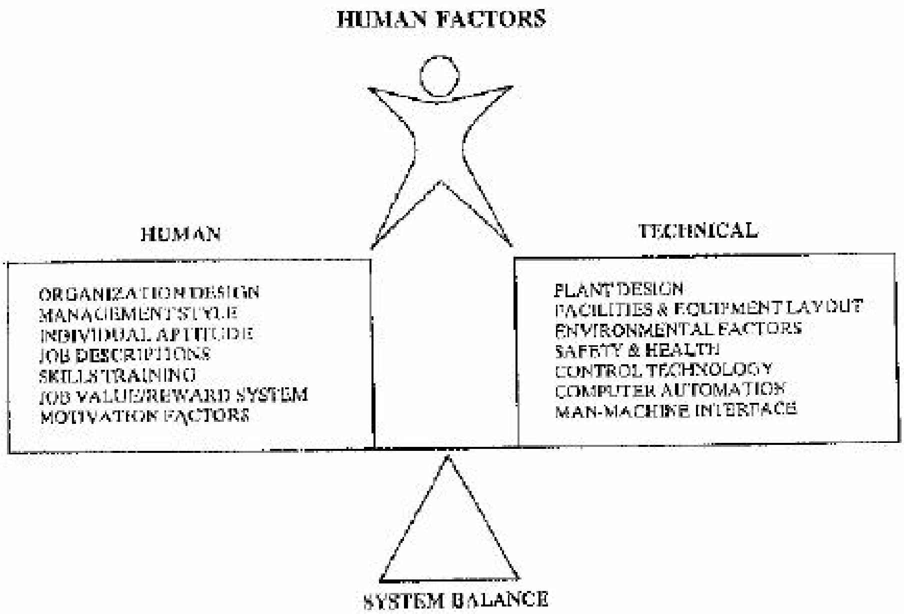

Figure 15.1

An enterprise should identify Human Resources (HR) as one of the essential components of project planning. It is essential that HR experts be associated from the beginning. The knowledge of practices in other progressive enterprises in India and abroad will be helpful in identifying areas where HRs are to be given greater, importance along with the machines. To illustrate, the factors responsible for poor productivity or unsatisfactory results which may have a bearing on the fuller utilisation of technology potential may include:

i. Resistance to change
ii. Poor educational background or preparation
iii. Shortage of skilled manpower
iv. High Turnover of employees
v. Poor documentation
vi. Poor maintenance
vii. Lack of proper attitude and motivation
viii. Inadequate monitoring facilities
ix. Lack of opportunities

An analysis based on the above factors will not only help the enterprise in identifying right HR strategies and action plans but will also help in the long term for balancing the technical and human components for exploiting full potential of technology.

While organising technology, the following aspects may help in achieving better results (see Figures 15.2 and 15.3).

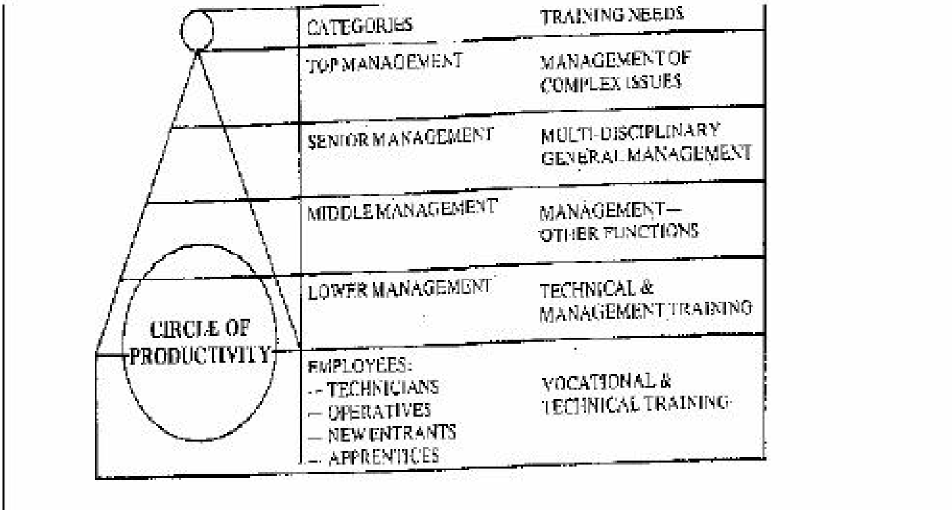

Figure 15.2: Training Needs of Employees

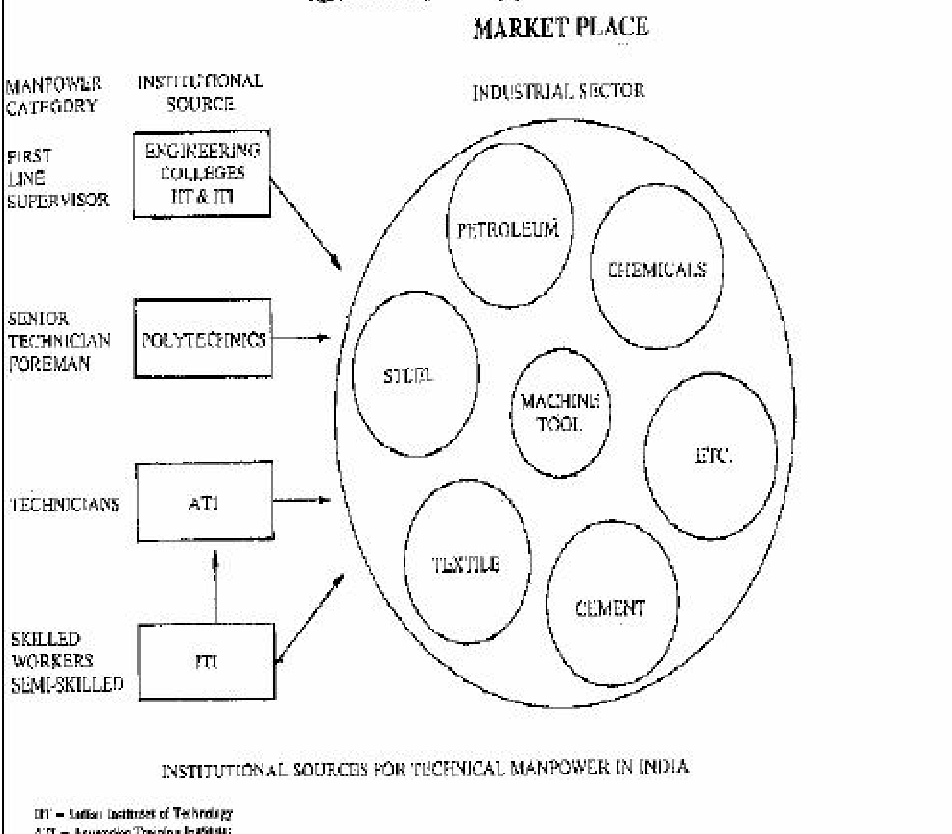

Figure 15.3

a) Categories of HR required should be defined. The categories may relate to

   a) Managerial
   b) Supervisory
   c) Operations

b) The sources for HR should looked into. The sources could be: i) existing employeein the enterprise or elsewhere, ii) employees in competitive enterprises, non-resident Indian abroad, iii) institutional sources-institutes/ Polytechnics/ Industrial Training Institutes (ITIs)/others, iv) training organisations, etc.

An enterprise should be viewed as a Human Performance System. A human performance system should incorporate the following major components:

- Top management leadership
- Recruitment and selection
- Job design
- Salary/incentives
- Performance appraisal
- Systems approach
- Training and development

Performance Oriented leadership

Leadership requires structures which can be used to support, perpetuate and motivate the entire organisation. This can be achieved by linking with each other the selection, training, upgrading, retraining, evaluation, compensation and promotion in jobs throughout the company. If management becomes alienated from the day-to-day operation and maintenance of plants it sends powerful signals of non-concern throughout the organisation. The traditional hierarchical organisation with too many layers of middle line personnel (which appear to be quite common in many plants) confound the communication process. Many companies need to examine their organisational approaches, particularly at the plant level. A typical plant organisation is given in Appendix. In the emerging competitive situation only that much manpower which is considered essential for the operation should be employed. This is the "circle of productivity" in Figure 15.1 and should be distinguished from other levels for training or for those not expected to participate in the production process (e.g. excess labour force which has to be kept due to social considerations).

Recruitment and Selection

Given the long lead time and expense of training, the first step for developing a, competent workforce is the proprer recruitment and selection of personnel. If suitable and competent personnel is recruited, it would minimise the expenses on training. Hence the primary goal of plant management should be the recruitment of the, most competent personnel at all levels within the "circle of productivity". Recruitment also means development of the sources of manpower supply. As indicated earlier, the needed manpower may be drawn through advertisement, , employment exchanges or agencies, from present employees, existing plants, educational institutions, etc. Given the rather wide variations in educational excellence from state to state in India, the competence of the personnel at the entry level must be carefully assessed through proper and objective selection procedures. Selection procedures ane needed for other personnel as well. There are a number of fairly relible and predictive tests which should be incorporated as part of a selection model. The tests most commonly used are:

- Performance tests: seek demonstration of capabilities
- Aptitude tests: seek to predict potential ability
- Personality tests: seek to determine motivation and personality
- Situational tests: seek problem-solving capabilities by presenting problems

Training and Development

The effectiveness of inhouse training over institutional training has been demonstrated. How and what the firm trains is critical. Trianing should provide experiences that can develop or bring about necessary modifications in an employee's behaviour so that he works efficiently and achieves the required goals.

Training is invariably required in all industrial firms. New people enter companies, changes take place within companies, people change as companies do. The development of new systems and technologies means continual training. The key question is whether training is being done effectively or not. Because training function is vital, it can increase productivity, reduce waste, increase safety, boost morale, etc.

The essential factors that must be kept in mind in organising training are: firstly, it must be an integral part of the total management system. In other words it should embody a total philosophy of the firm and must be accepted in principle by top management. Secondly, the training function should not be completely handed over to a separate training department. Training is done all the time when people are together in the work situation. Training should be a continuous responsibility of the line personnel. The training department must realise that it performs the role of a Systems facilitator in the actual process of training. The training department must advise and co-ordinate the training functions. The line personnel should be called in to help to design the system. Since the manager of a line function is ultimately responsible for the results of that function, it is he who should be consulted. The closer the training is to the actual performance, the more potent the effect on productivity.

Activity 4

Identify, with regard to your own organisation, various groups/agencies, involved in the management of technology and analyse their roles and linkages. Draw out a chart of organisation influence structure.

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Activity 5

Draw out a chart of the structure for the monitoring of technology transfer process in relation to any one specific case you might be familiar of.

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15.10 SUMMARY

In this unit we had a closer look at some aspects of technology management and this we did more specially from the viewpoint of an industrial enterprise, These aspects include technology strategy, technology gaps and enterprise needs, evaluation of technology options and sources of technology, technology transfer and absorption, R&D organisation and its role and resource management. It was pointed out that industrial enterprises, particularly in high-tech sectors, may have to import technologies. However, sufficient attention will have to be paid to develop adequate in-house technological capabilities for absorption and upgradation of imported, technologies so that we are able to minimise further imports. As an example, in our discussion about Indian Cement industry, some areas such as energy conservation were indicated which require more concentrated efforts on the part of the industry. It was also mentioned that while cement and machinery manufacturing industries, by and large, had successfully absorbed imported technologies, yet there is further scope for developing greater technological capabilities for meeting the emerging requirements in relation to costs and technical excellence.

15.11 KEY WORDS

R&D organisation: A segment of the organisation responsible for in-house R&D activities to meet technology development and technology transfer needs.

Monitoring Technology Transfer Process : Keeping track of the actual events in relation to commitments made by the licensor and the licensee and the understanding reached, ensure that all the elements of technology e.g., designs and drawings, technical specifications, sourcing of materials, and components, training, quality control and standardisation procedures etc. are effectively taken care of.

Energy Conservation : Technological efforts to reduce energy consumption and optimisation of the existing energy usage.

15.12 SELF ASSESSMENT QUESTIONS

1) What is technology acquisition? Give an example (i) of an existing enterprise; and (ii) of a new enterprise where technology has been acquired.

2) What is likely to be the impact of new industrial and trade policies on technology management of a high tech company such as in electronics or computers?

3) What are the modes of transfer of technology and how can these be evaluated? Suggest some possible modes for transfer of technology for traditional sector such as cement, and modern sector such as electronics or information industry.

4) What is meant by multidisciplinary approach to technology evaluation? Give an example.

5) What measures at enterprise level are necessary for successful absorption of imported technology by the recipient? Give an example of an enterprise or industry where imported technology has been successfully absorbed.

6) How could R&D be used to get benefits from technology transfer? Discuss the role of Technology Management Group of a company in affecting technology transfer at most favourable terms to the company.

7) Draw out a possible organisation (structure) chart for evaluation and monitoring of technology transfer through technology acquisition. Would the structure be different if technology is adapt from inhouse R&D?

8) Draw out a plan of action for an enterprise for transfer of technology. What is meant by Capital Goods (CG) imports? Discuss.

9) What is your opinion about "Exim Scrip" policy of the Government in relation to the foreign exchange requirements for technology transfer payment, import of capital goods and other inputs? Has the policy been changed? What changes have been effected?

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APPENDIX

Technology Management in Indian Cement Industry

Technology Transfer Scenario in Cement Industry

Cement Industry has not only recorded substantial growth since independence (from about 1 million tonnes to 63 million tonnes capacity) but also has undergone dramatic technological change. Starting with high energy intensive, high manpower and practically no instrumentation, the industry now is high energy efficient, employs low manpower and has state of art instrumentation, including automation with expert system. The industry from a stage of having 97% of its capacity under the wet process has now 80% of its capacity under the dry process system. The compulsion for change was from energy point of view which in terms of fuel requirement had to be reduced to half of what was then for each unit of cement produced. This study gives features of the technology changes which have taken place and are still underway. The study is based on the proceedings of the national workshop on energy management in Cement Industry held at Hyderabad on 29th August, 1991.

Industry Profile

The Cement Industry has recorded substantial growth in the past four decades. The installed capacity which was about three million tonnes in 1950 has shot up to about 64 million tonnes in 1990-91. The actual production of cement in 1990-91 was 48.75 million tonnes representing an average capacity utilisation of 76%. The cement demand at the end of 1994-95 is expected to be around 65 million tonnes. This implies that at the average capacity utilisation of 75% the installed capacity needed by 1994-95 would be around 85 million tonnes requiring an additional capacity creation of 21 million tonnes in the next four years. But, the current indications are that the installed capacity by 1994-95 would be only about 75 million tonnes implying shortfall of 10 million tonnes.

The structure of Indian Cement industry has undergone a significant change with respect to plant size and process employed. The industry has grown phenomenally in the last six years and after the cement decontrol and liberalisation policies, the industry is enjoying good times now with booming markets and better realisation of prices. But this is not a matter for complacence but an opportunity to aim at higher capacity utilisation, adopt energy efficient technologies, etc. In the past decades, there has been a general shift towards dry process plants which are energy efficient compared to wet process. At present there are still 71 wet process kilns representing 16% of the industry capacity. Though in terms of units wet process kilns represent 43%, their share in production capacity is low at 16% due to lower ratings ranging between 200 to 600 tonnes per day (tpa). The industry is now witnessing a steady move to higher capacity rating kilns of 1.0 million tpa. Further, some companies are already moving toward 1.5 million tonnes per annum capacity cement plants. Many Indian cement plants have already adopted latest technologies such as the precalciners which facilitate the use of high ash coals and lime stone of inferior quality which leads to substantial fuel and electricity savings.

Energy Consumption Trend

Cement manufacturing is an energy intensive operation with energy accounting for about 30% of the production cost. In terms of direct manufacturing costs, energy constitutes 60% of the total direct costs. This sector consumes about 10 million tonnes of coal and 5.5 billion units of electricity. Of the total estimated demand in the industrial sector, the coal requirement in the cement industry accounts for 5% and power requirement 4.5%.

Systematic studies have been conducted in the country and abroad and what follows hereinafter has been identified as the technological improvement areas. All these areas not only relate to energy conservation but also to adapting state of art technology.

Energy Conservation Approaches

Considering the vast magnitude of potentiality for energy savings in cement plants, it would be worthwhile classifying the options under following categories:

Stage 1 : Operational improvements and optimisation measures and efficient electrical load management.

Stage 2 : Retrofit (modernisation, expansion etc. of old or existing plants) options for energy conservation through improved process controls, capacity enhancement etc.

Stage 3: Adoption of state of art technology for energy efficiency improvements.

Energy Conservation opportunities

- Energy conservation opportunities in operational improvements and optimisation.
- Energy conservation opportunities through process controls, capacity enhancement/add-on devices.
- Energy conservation opportunities through adoption of state of art technology.

Appropriate technologies cover the following broad areas;

a) conversion of wet process plants to dry process plants

b) conversion from preheater technology to precalciner technology.

c) conversion of planetary cooler system to grate cooler system.

d) adoption of vertical roller mille in place of the traditional ball mille for grinding of raw meal and coal etc.

e) adoption of the state of art micro processor based controls for effective process control and energy conservation.

f) use of alternative fuels such as lignite and natural gas in the case of plants with precalciner technology.

g) adoption of on-line composition analysers to monitor and maintain raw meal mix in order to optimise on kiln heat consumption.

h) simulation pilot plants for analysis of grindability index of raw meals, clinker and coal to enable judicious blending for grinding energy reduction.

i) adoption of bucket elevator conveying system in place of pneumatic conveying system.

j) adoption of rope way for material transport in place of traditional dumper system which is more energy intensive.

Table 1 gives the energy consumption pattern of Indian Cement industry.

Table 1

Energy	India	Developed Countries	Gap	% Difference
Electrical Energy				
(kwh/tonnes of cement)				
Wet Process	121	87	34	+ 39
Dry Process	129	110	19	+ 17
Thermal Energy				
Wet Process	1510	1243	267	+ 21
Dry Process	896	769	127	+ 17

The power consumption in cement manufacturing is mainly spent in grinding and handling operations and nearly seventy per cent of it is consumed in raw material grinding, sintering and cement grinding systems. The energy consumption pattern is found to vary from one plant to another due to factors such as:

a) Age of the plant

b) Type of process adopted

c) Plant size capacity and system, design

d) Plant layout and material handling system

Hence there cannot be a universal standardised approach towards conservation and each plant is required to be examined on its own merit.

Energy audit has to be done periodically to monitor efficient use of energy. This would include studying various operations using energy, and equipment and examining their relative efficiency/performance and adopting energy conservation methods.

Mobile energy diagnostic unit (energy bus) which is a unique facility equipped with latest and sophisticated measuring facilities and on-board computer with relevant software for faster and accurate assessment of energy use pattern is available in the country, and can be used in cement plants..

Number of cement plants in the country have adopted some of these measures in various combinations and have improved energy efficiencies. This has been achieved partially through technology acquisition and partially indigenous effort. The absorption of technology for equipment, process, operations and quality control has been of very high order and it is hoped that the remaining gaps will be further narrowed down from continuous technology development and upgradation efforts on the part of machinery manufacturers, cement manufacturers and related R&D institutions. It may be mentioned here that most of the cement machinery manufacturers had technical foregin collaboration arrangements and are producing plants based on those imported technologies. Many cement plants with huge capacities such as Modi Cement and Gujarat Ambuja Cement have been built up with imported technologies from USA and other countries. While cement plants in India have quality control and testing facilities they have really not created any substantial R&D facilities, baring a few only such as Dalmia Cement and ACC. Most of them depend on the foreign technical support or support from machinery suppliers.

National Council of Building Materials (NCBM) at New Delhi, Central Building Research Institute at Roorkee, ACC Research Station at Thane (Bombay) are some of the main R&D institutions related to cement industry. The cement costs in India are not internationally; competitive due to various factors including technological deficiencies. Pollution control, waste utilisation, optimisation of operations are some other areas which need more attention of the cement industry.

Uttar Pradesh
Rajarshi Tandon Open University

MBA-4.4
Technology Management

Block

6

CASE STUDIES

S. No.	Title of the Case/Note	Author/Contributor
	Analysing a Case	Prof. M.L. Bhatia, SOMS, IGNOU
1.	Central Electronics Ltd.	CEL, Sahibabad
2.	Eicher Tractors Ltd.	Prof. Shekhar Chaudhuri, IIM, Ahmedabad
3.	ESAB India Ltd.	Dr. S. Bhattacharya, General Manager, R&D and Quality Assurance, ESAB India Ltd.
4.	Hindustan Tractors Ltd.	Prof. K.R.S. Murthy, IIM, Ahmedabad
5.	Indian Iron & Steel Co. Ltd.	Mr. V. Rangarajan and Mr. Anathnarayna Sarma, Centre for Organisation Development, Hyderabad
6.	Punjab Tractors Ltd.	Prof. Shekhar Chaudhuri, IIM, Ahmedabad
7.	Rice Husk Board	Dr. S.T. Narayna Swamy, Chief Engineer, NRDC, New Delhi

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LOCK 6 CASE STUDIES

s block consists of seven case studies. Some of these case studies have also been used for some other courses he Management Programme, viz., Corporate Policies and Practices (MS-11), and Strategic Management (MS- Because these case studies have in them technology as their dominant characteristic, we thought they were vant for this course as well. While a few cases may be considered more closely related to one or more cific blocks (for instance, Case 1: Central Electronics Limited is predominantly concerned with Technology eration and Development), other cases touch upon several elements/aspects of Technology Management (for ance, Case 4: Hindustan Tractors Limited). As such the latter type of cases are more general in nature. You find three cases on "Tractor" industry. This is partly intentional. The inclusion of these cases belonging to the e industry should enable you to grasp the necessary details of the Tractor industry, its environment, the petitive situation, and the place and policies of the important players vis-a-vis each other.

ı may seldom find a case which exclusively deals with Technology Management. More often than not, you l find that a case touches upon several other aspects of Management e.g. Financial Management, Marketing nagement, Human Resource Management, etc. The various aspects of management of functional areas, luding manufacturing, production or operations management, are often interwoven. Therefore, your analysis y not be limited to technology areas alone but may extend to several other areas which are germane to or inge upon Technology Management.

hough it is always desirable first to expose yourself to the literature or readings in Technology Management ich are contained in your course material (booklets 1 through 5), and then attempt the analysis of the cases, vever this procedure need not be strictly followed. You may not hold the analysis of cases till you have read the booklets. Even after reading one booklet you may proceed to attempt one or more case studies, and the ation may be repeated. Needless to say, it would be desirable to go through the analysis of the cases once in after you have read all the booklets and note the points you had missed earlier and the additional insights readings of the further material have enabled you to gain. Before you proceed to analyse the cases, it will be your interest to thoroughly read next section "Analysing A Case" where we have attempted to describe the case thod, its objectives, benefits and the ways of preparing and analysing a case.

ANALYSING A. CASE*

1.1 WHAT IS A CASE

A case is written description of an organisation (or any of its parts) covering all or some of its aspects for a certain period of time. It sets forth the events and organisational circumstances surrounding a particular managerial situation. Most cases contain information about the organisation's history, its internal operations and its external environment. Though there is no standard order of presentation, many cases include information about, the industry, the competitive conditions, the products and markets, the physical facilities, the work climate, the skills and personality of managers, the organisational structure, together with the financial and quantitative data relating to production, marketing, personnel, and so forth. Cases may relate to profit seeking, government or public service organisations.

A good case places students in a realistic situation where they can practise making decisions. Though a case may contain plenty of information, in some cases running into several pages, there is no such thing as a truly complete case. Students often say (or complain) that they have too little information in the case. While this may be true, it should be appreciated that, many a time, managers in the real world too have information which can hardly be described as sufficient. In fact, a manager has far less opportunity for study and interaction with others as a student has. The managers cannot afford to delay making decisions until they are satisfied with the quality and quantity of available information. Such, a time perhaps may never arrive. Like a real world manager, a student must make a decision, making best use of whatever information is available and making assumptions about whatever is unknown or is not available.

1.2 OBJECTIVES OF CASE METHOD

The objectives of the case method are to:

- help you to acquire the skills of putting text book knowledge about management into practice. Managers succeed not so much because of what they know but because of what they do.
- get you out of the habit of being a receiver of facts, concepts and techniques and get into the habit of diagnosing problems, analysing and evaluating alternatives, and formulating workable plans of action.
- train you to work out answers and solutions for yourselves, as opposed to relying upon the authoritative crutch of the teacher/counsellor or a text book.
- provide you exposure to a range of organisations and managerial situations (which might take a life time to experience personally), thus offering you a basis for comparison in your working as a career manager.

Reading books, articles and listening to lectures alone cannot develop managerial skills. For most managerial problems, readymade answers do no exist, or perhaps cannot exist. Each situation is different, requiring its own diagnosis and evaluation before action can be initiated. Case studies allow learning by doing to occur. They stimulate the reality of a managerial situation and a manager's job. In a sense, cases are laboratory materials and offer a reasonanle substitute for actual experience by bringing a variety of management problems and opportunities into the class room.

Students often ask their teacher/counsellor, "What is the right answer/solution?" If the discussion in the class concludes without clear answers or a clear consensus on what actually happened or what should/ought to be done, some students feel frustrated, While in some cases it would be possible for you and the counsellor to develop a consensus, in other cases it may perhaps not be possible, As in real world, hard answers to cases do not exist. Therefore, issues are discussed and various alternatives and approaches are evaluated. Usually, a good argument can be made for more than one course of action. The important thing for students to understand incase analysis is that it is the exercise of identifying, diagnosing, and recommending that counts rather than discovering the "right answer". The essence of case analysis is to become skilled in the process of designing workable action plans through evaluation of the prevailing circumstances.

* Written by Prof. M.L. Bhatia, School of Management Studies, IGNOU.

If case method rests on the principle of learning by doing, it all depends on you as to how much gain you can derive by making your own analysis and reaching your own decisions, and then participating in the class room in a collective analysis and discussion of the issues. Since a case assignment emphasises student participation, it is obvious that the effectiveness of the class discussion depends upon each student having studied the case before hand. A case assignment therefore requires conscientious preparation before class. You cannot expect to get much out of hearing the class discuss a case with which you are unfamiliar or not fully prepared for.

The pedagogical objective of *case* method is very much different from the usual teaching in the class room. Instead of the professor/instructor/counsellor, it is the students who do most of the talking. The counsellor/ instructor's role is to solicit student participation and guide the discussion. The counsellor might begin by restating the questions given at the end of each *case* or he might even propose or frame some new questions, like: What is the organisation's strategy? What are the strategic issues and problems confronting the company? What is your assessment of the company's situation? Is the industry *an* attractive one to be in? Is management doing a good job? Are the organisation's objectives and strategies compatible with its skills and resources?

The students are expected to engage in discussion with each other, with the counsellor listening to them patiently and providing direction/guidance *as* and when required so that the whole discussion remains on the track. It is the students who carry the main burden of analysing the situation and then presenting and defending their analysis in the counselling sessions.

You should therefore not expect your counsellor to say: "Here is how to do it", "Here is the right answer", etc. Although you should do your own dependent work and thinking, you should not hesitate to discuss the case with other students.

1.3 BENEFITS

The case method offers students an opportunity to communicate and convince their fellow students and their counsellors of the correctness of their viewpoints. This is analogous to the situation where a manager must persuade others to accomplish organisational purposes. The case analysis and discussion help the students in developing analytical, communication and interpersonal skills which are vital for success in management. The method also provides some opportunity to the students to relate their viewpoints with those of the others. While defending his own viewpoint, a student has also to develop an appreciation for the viewpoints held by others. Table 1.1 lists the management skills which are improved by case analysis.

Table 1.1 Action Skills Reinforced by Cases

1) Think clearly in complex ambiguous situations. Successful experiences with cases give students the practice and confidence necessary for clear intensive thinking in ambiguous situations where no one right answer exists. Since problems in management and administration are full of these situations. The skills are valuable to acquire.
2) Devise reasonable, consistent, creative action plans. Most cases require the student to detail a course of future action.
3) Apply quantitative tools. The management of modem organisation demands the use of such quantitative tools and theory as net present value, ratio analysis, and decision free analysis. Active employment of these techniques in actual situations requires more knowledge than one typically gains by introductory theory and problems. Cases give the student practice in using quantitative tools in these realistic situations.
4) Recognize the significance of information. Theories and observations of modem management have shown that managers sift through large masses of information, both formal reports and informal channels (the "grapevine"). The manager's task of defining problems and their solutions demands the ability to classify information.
5) Determine vital missing information. Successful decision makers must know where and be able to determine when to seek more information. Cases give the student practice in solving problems with the information at hand in the case. In researching standard industry sources, and in identifying the missing information that is vital to the formulation of an action plan.
6) Communicate orally in groups. Both the in-class discussions of cases and small group discussions preceding class are an integral part of learning by cases. The ability to listen carefully to others, to articulate one's views, and to rapidly incorporate the views of others into one's position are all important skills for managers.
7) Write clear, forceful, convincing reports. Managers and their staffs have to express themselves in writing. The best way to improve one's writing skills is to write; hence, the usefulness of the case

report.

8) Guide students' careers. Many students would benefit from a greater awareness of the day-to-day tasks and responsibilities of managers. The wide variety of actual situations described in cases gives students valuable knowledge about the functions of many job positions.

9) Apply personal values to organisational decisions. Modem industrial society forces managers to make decisions which trade among business profits, government expenses, and the welfare of individuals and the public. This area of ethics and social responsibility is important and problematic in a professional education. The process of stating and defending positions in case discussions sharpens a student's awareness and maturity in the subjective area of value and moral judgements.

Source: Edge, Alfred G. and Denis R. Coleman, 1981. The Guide to case Analysis and Reporting. Systems Logistics: Honolulu, pp. 5-7.

1.4 ANALYTICAL TOOLS

There are a number of tools which have been found to be useful, both academically and professionally. Among the more important ones are:

- SWOT Analysis
- Ratio Analysis
- Portfolio Analysis
- Checklist (Technology audit)

SWOT Analysis

The first thing that an analyst should do in SWOT (strengths, weaknesses, opportunities and threats) analysis is to. define the business of the organisation and identify the key factors for success. The student must evaluate the strengths and weaknesses. in terms of the skills, resources and competencies of the persons with the company in the light of the key factors. The analyst then should see whether the internal capabilities match with the demands of the key factors so that the company will be able to exploit the opportunities and fight off the threats.

The SWOT analysis stands at the core of any type of management whether it is strategic management or technology management. The job of the. organisational manager is to capitalise on the organisation's strengths while minimising the effects of its weaknesses in order to take advantage of opportunities and overcome threats in the environment.

Threats and weaknesses are relative rather than absolute. Opportunities seldom simply arise. Many a time they exist in the environment and only need to be identified. For example, it is expected that a market might emerge in the foreseeable future for the low cost home computers at least in the metropolises of. India. A computer company which has the ingenuity and energy to make and market such an item will have the opportunity to become the dominant home computer maker for several years. Opportunity thus requires potential new initiatives. While most opportunities have to be sought, in some cases they have even to be created. R&D allows opportunities to be created. The main focus of the corporate strategist should be to identify additional opportunities, selecting the ones that are most promising and capitalising on them.

Like opportunities, threats also exist or emerge as a result. of new developments, expected or unexpected. Threats . become less severe if they are recognised and guarded against. Various strategic alternatives discussed in Block 5 may help a company overcome or minimise the effect of threats. When a threat is recognised soon enough, it can often be converted into an opportunity.

SWOT analysis is a useful aid for generating alternatives. become quite complex, To simplify the process, you opportunities and threats in the following format:

Strengths	*Weaknesses*
Opportunities	*Threats*

As an analyst, you might find it difficult to neatly classify much of what is of strategic importance into the above four categories. This is also true of the real would.

Ratio Analysis

Financial ratios are widely used for analysing and interpreting situations of strategic importance. The financial ratio analysis somehow gives the impression that only an economic view of business is being taken. Undoubtedly, human and social considerations are equally important. While ratio analysis is a valuable tool in revealing potential problems, it should not be used alone. Ratio analysis is just one of the many tools the analyst has available in his kitty for evaluating corporate performance.

Portfolio Analysis

The techniques of portfolio analysis are particularly useful for analysing the strategies of diversified enterprises. The two widely used and accepted matrices are: BCG Matrix (Growth-share Matrix), and Shell Directional Policy Matrix (DPM).

Checklist (Technology Audit)

A checklist, developed on a comprehensive basis, can also be a useful device for analysing a case. In the context of technology management, a comprehensive checklist is more or less synonymous with technology audit which represents an integrated view of technology management process in action and covers its key aspects. Audit considers not only how objectives, strategies and policies are formulated but also how they are implemented, evaluated and controlled. "The technology audit, therefore, enables a person to better understand the ways in which various functional areas are interrelated and interdependent, as well as the manner in which they contribute to the achievement of the corporate mission." Strategic audit is very useful for those people, such as the board of directors, who are interested in evaluating the performance of the company and its management.

Strategic audit may be conducted along the various questions contained in Appendix I. These questions are useful in analysing a complex case on corporate policy. Though not all-inclusive, the Appendix presents many critical questions needed to strategically analyse a business organisation. You may take this list as *a guide* for your analysis. Some questions (or even some areas) may be inappropriate in a particular case, while in some other case the questions may be insufficient for a complete analysis. However, each question in a particular area can be broken down into additional series of sub-questions. Strategic audit thus provides a systematic framework for analysis of complex cases.

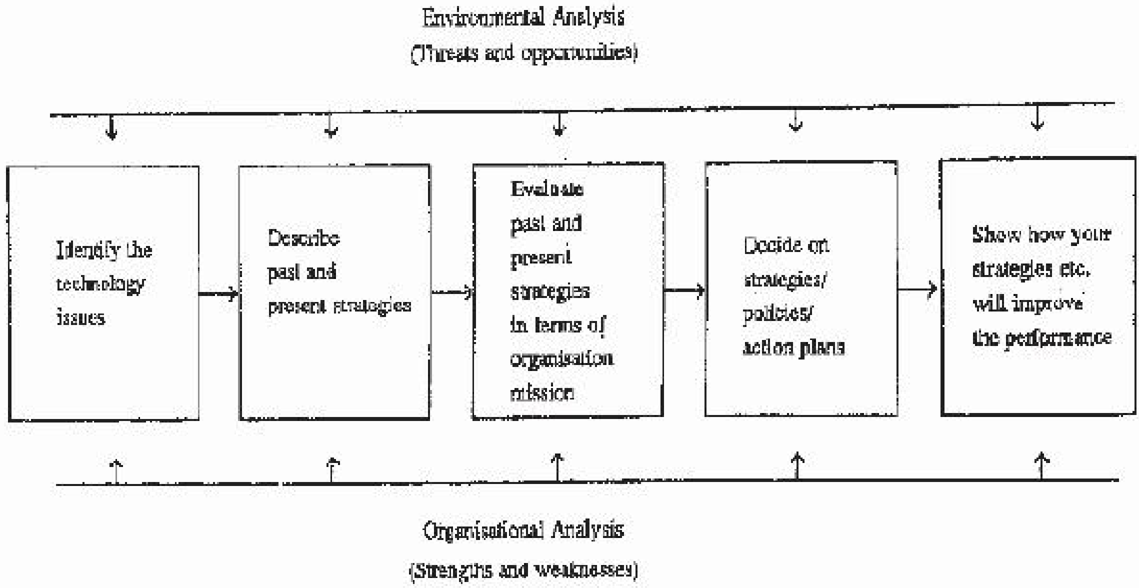
1.5 PREPARING A CASE

A case may be prepared for:

- Oral analysis for discussion (by individuals)
- Oral analysis for discussion (by groups)
- Written analysis (by individuals)
- Written analysis (by groups)
- Oral/written analysis and presentation (by individual/groups)

What particular method would be followed in the counselling sessions would depend upon the thinking of the counsellor and other factors, including the nature of the company and the length of the "case. For many students, this will tie their first real exposure to case analysis. For facilitating your analysis, we have given or posed some questions at the end of each case. You may analyse the case along these questions and in the process follow the line of action as shown in Figure 1.1.

Fig. 1.1: A Guide for Case Preparation



The counsellor may ask one of the students who has prepared the case to make a presentation on one of the questions. This can then be followed by an open discussion. After all the questions have been covered one by One, the case as a whole can then be thrown open for discussion. The counsellor toward the end can sum up the whole analysis and draw some conclusions. Whether the counsellor asks for oral discussion or written presentation, it is always advisable to prepare a written analysis. Apart from several other benefits, it will bring to the case a thoroughness which is generally not expected when you. prepare for oral discussion.

While no standard procedure can be laid down, the following successive steps will be helpful for analysing the case (whether for oral discussion or written presentation):

- know the facts
- understand the environment of the organisation (external and internal)
- gather relevant information from outside sources, if necessary
- appraise and evaluate the environment
- consider and keep in mind the mission of the organisation, while making recommendations.

A case is a technical paper. As such it deserves careful reading. A good approach is to read the case three times: once rapidly, scanning quickly any exhibits; a second time thoroughly and slowly, putting careful attention to the exhibits and making some notes about apparent organisational objectives, strategies, symptoms of problems, root causes, unresolved issues and the role of key individuals; and a third time rapidly again to reinforce the main points.

While analysing the case, try to look for issues beneath the surface. For instance, at first glance, the issue might appear to be whether or not there is ample demand for the product at the current selling price. On closer examination; you might find that it is the method of compensating or providing incentives to the sales force that is standing in the way of achieving higher sales volume.

To help diagnose the situation, put yourself in the position of the manager or managerial group portrayed in the case and get attuned to the overall environment facing the management. You may expect the case to contain several problems and issues rather than just one.

Sometimes a case may not contain all the information that you think is necessary for analysing the case. This may be particularly true with regard to data on external environment, competitors and industry characteristics. This often requires library research using business magazines, trade journals, company Annual Report, etc. While searching for information, it should be borne in mind that all facts are not equally important. A systematic approach to information gathering should be followed. Some sources from where you could gather necessary information are listed in Appendix III.

While analysing'and recommending any course of action, you may always keep in mind the mission of the organisation. Ultimately, all aspects of strategic management must be related with the mission of the organisation. For ascertaining the mission of the organisation, you may attempt to answer this question: What is the organisation trying to do and for whom? In examining the mission of the organisation, you may consider from both descriptive and normative standpoints. Where necessary, you may not shy away from taking a normative view and evaluating management from an ethical or moral standpoint:

The arguments you make and the positions you take should be defensible and supportable with evidence (statistical data, calculations, etc.). Your objective should be to develop what you think is a pragmatic, advisable course of action that is based on a serious analysis of the situation. Someone else might have evaluated the same facts in another way and thus has a different "right" solution. While defending your own answer, you should also try to relate it with the answers of other participants and try to appreciate the reasons behind any difference. Though the case method is a group process, it does not imply conformity to group opinion. Sometimes one has to swim against the tide of majority opinion. In the practice of management there is always room for originality and unorthodoxy.

While discussing or arguing your point, you can assume that the other participants know the facts or what "the case says". Therefore rehashing the information should be held to the minimum except when you need to document, compare or support your position. Be as specific as possible in your comments and provide comparative data. Take for instance: the slight growth in market share from 10 per cent in 1985 to 11 per cent in 1986 was achieved during a general recession and in an industry growing at about 8 per cent annually. While analysing, recognise the distinction between facts and opinions given in the case.

Once you have thoroughly diagnosed the company's situation and weighed the pros and cons of various alternative courses of action, you may decide on what the company should do to tackle the problems or improve its performance. Draw up your set of recommendations and prepare an "action agenda". This is the most crucial part of the analysis. Bear in mind that proposing realistic, workable solution is not the same as offering a hasty, or not a properly conceived possibility. Do not recommend anything you would not be prepared to do yourself if you were in the shoes of the decision maker.

1.6 WRITTEN PRESENTATION

We had earlier suggested that even where your counsellor has asked you to prepare your analysis for oral discussion in the class, it is advisable to analyse the case in writing. Your counsellor sometimes may specifically ask you to do a written analysis so that he could evaluate your analysis and provide you with some useful feedback. A written presentation is a more structured approach to case analysis. Just as there is no set formula for preparing a case for oral discussion, so there is no set procedure for a written case analysis either. If questions are given in the case, you may attempt your analysis based on those questions. In case no questions are given, you may attempt a comprehensive written analysis (without being unduly lengthy) on the lines suggested in Figure 1.1.

In written presentation you should avoid repetition, exaggeration and over-generalisation. If your analysis involves some important quantitative calculations, then you should use tables and charts to present the data clearly and efficiently, You can also use flowcharts and diagrams where appropriate. Use sub-headings to organise your report and put all your analysis in a logical sequence, It is not advisable to just tack the exhibits at the end of your report and let the reader figure out what they mean and why they have been included. Instead, cite some of the key numbers. and summarise the conclusions (to be drawn from the exhibits) in the body of the text itself and refer the reader to the charts and exhibits for more detail. It goes without saying that your report should be properly organised and written in a communicative and persuasive manner.

While stating your recommendations, see that they are in sufficient detail so as to be meaningful. Simply making a statement like "the firm should improve its market position", or "the organisation should do more planning" is not enough, You must explain what you think must be done. You must say how your plan should be implemented. In other words, offer a definite agenda for action, stipulate a time-table and sequence for initiating action, indicating priorities and suggesting who should be responsible for doing what.

1.7 WHAT AN EVALUATOR LOOKS FOR IN A CASE ANALYSIS

The important elements that a counsellor (or evaluator) would generally look for in a case analysis are:

- care with which facts and background knowledge have been used
- ability to state problems and issues clearly
- use of appropriate analytical techniques
- evidence of sound logic and arguments
- consistency between analysis and recommendations
- ability to formulate reasonable and feasible recommendations for action.

1.8 CONCLUSION

Case preparation and presentation is challenging as well as rewarding. As you develop and refine your skills (which are perhaps not as obvious as the knowledge gained in a lecture), you find that they apply to numerical situations in your professional and personal life. Remember that each case requires significant amount of time you are really interested in making a good analysis. Without this, case analysis will not do much good to you.

Appendix 1: Check List for Technology Audit

I Current Situation

- What are the company's current technological strategies, objectives, policies or approaches? Are they clearly stated. Are the strategies, objectives or policies consistent with each other, and with the internal and external environment?
- How is the company performing in terms of its stated technological, objectives, strategies and policies?
- How does the technology of the company compare with the technology of its close rivals, similar companies or industry as a whole?
- What. are the short-term and long-term technology problems facing the company.

II Evaluation of Technology Strategy

- Does the company have a technology based competitive advantage? How long the advantage is likely to continue? What can the company do or should do to strengthen or maintain its competitive advantage?
- What kind of technology alternatives the company has been following and why? Does the company need to have new technological thrusts or initiatives? What new technologies/products does the company need to add and what technologies/products it needs to shed?
- How would the new technological thrusts/initiatives solve the short-term and long-term problems?
- Is the technology strategy well integrated with the overall business strategy?

III Manufacturing

- What are the company's current manufacturing objectives, strategies, and policies? Are they clearly stated? Are they consistent with the company's mission, objectives, strategies, policies, and with internal and external environments?
- What are the manufacturing capabilities of the company in terms of plant facilities, type of production system, extent of mechanisation and automation, utilisation of capacity, etc.?
- What is the relationship between fixed and variable costs? How well are the operational activities being performed in the sphere of inventory control, material handling, etc.?

- What is the role of manufacturing/production manager in the process of strategy formulation and implementation?
- Are manufacturing managers and supervisors using the right concepts and techniques in terms of cost systems, quality control, inventory control, learning curves, safety programmes, value engineering, etc.?

IV Research and Development (R&D)

- What are the company's current R&D objectives, strategies, and policies? Are they clearly stated? Are they consistent with company's mission, objectives, strategies and policies, and with internal and external environments?
- Is the company in high-tech, low-tech or medium-tech area?
- Is the company working in a relatively stable or fastly changing technological environment? If the latter case is true, how is the company equipped to face the situation? Is the company technologically competent?
- What facilities have been created or exist for basic and applied research?
- How well does the company's investment in R&D compare with the investment of similar companies?
- What is the role of R&D manager in strategy formulation and implementation?

V Technology Management (General)

- At what stage are the various technologies in their life cycles? Are new technologies being planned, generated, developed or acquired?
- Are the current technologies appropriate to local conditions, community, environment preservation, legal requirements, etc.
- What is the national and international technology environment, including technology policies of the national and other concerned countries? At what pace are current technologies changing?
- How are the changes in relation to various technologies affecting the society/community? How are they likely to affect the company? What preparations have been or need to be made?
- How innovative the firm is or has been in the past or proposes to be in the future? What have been its achievements on the innovation front? What has been the nature of innovations-radical, incremental, etc.?
- What is international•. technology environment? What development, general and specific are taking place? Does the company have an adequate system of monitoring technology developments? How can the company benefit from technology developments?
- Does the company have a technology forecasting mechanism? If it does not have, what alternatives have been planned.
- Does the company have a technology search strategy? Does it have the capability of identifying technological opportunities? Does it have the capability including linkages) for effecting/airanging technology transfers?
- Are the acquired technologies being adequately absorbed? What action plans and evaluation mechanisms exist for technology absorption?
- Does the company have a diffusion policy for technology acquired or develdped? How is this policy being implemented?
- Do the supporting systems for technology exist within the company? Does the company have an adequate information system?
- Does the company have the financial' capability for converting technological opportunities into viable business propositions? Does it have adequate long-term funds for R&D projects, proposed acquisitions, generation or development of technologies?

CASE 1

CENTRAL ELECTRONICS LIMITED

Central Electronics Limited (CEL), a public sector enterprise of the Department of Scientific & Industrial Research was established at Sahibabad, U.P. in 1974, with the objective of productionising the designs and processes developed by our national R&D laboratories. During the first decade of its existence, CEL, brought into the market a great variety of products, producing them in the low volumes that the nascent electronics market was capable of absorbing, and generally competing with specialist companies abroad selling to a world-wide market. As a result, CEL came to be recognised as a technology-oriented company, which had painstakingly acquired skills and perfected technologies in several new and emerging areas. However, annual turnover remained at only a few crores of rupees, in spite of the impressively vast product portfolio.

At the beginning of the Seventh Five Year Plan, CEL conducted an intensive and soul searching review to determine the directions in which it should move so as to increase the satisfaction to its stake holders-the clientele who bought from CEL, the government which owned the equity, CEL's suppliers and its employees. This review indicated that the Company should aim at excellence in a few carefully chosen areas, in which the likely demands of the market place were well matched to CEL's existing strengths. The emphasis on technology should continue, but with greater attention to market realities and with better networking between interested agencies.

CEL's Mission: TO ACHIEVE EXCELLENCE IN THE TECHNOLOGY, MANUFACTURE AND MARKETING OF RENEWABLE ENERGY SYSTEMS AND SELECTED ELECTRONIC MATERIALS, COMPONENTS AND SYSTEMS clearly spells out the new focus and the interrelation of factors. With such an overall reorientation, CEL grew rapidly during the Seventh Plan (1985-1990), increasing its ,annual turnover by roughly a factor of eight through timely induction of several high technology products to be a Rs. 25 crore Company.

Market Driven Technology Development

By constant and critical examination of the market place, a company can determine the needs that will be possible for it to satisfy. Interaction with end-users and those in the distribution chain will identify the exact need of the buyer segment, the features that would be sought, the way the need is presently met and other products/services competing for the same resources. From this information, product specification, price target, identification of technologies required, production and marketing plans, etc. can be drawn up. A budget for time and other resources will also emerge.

Any product goes through induction, growth, maturity, decline and decay phases which taken together constitute the product life-cycle. R & D time should be short compared to such life-cycle. This however calls for early induction into the market of the company's product as against that of a competitor with corresponding prospect of large market share and hence larger revenues during the maturity and decline stages.

A variety of skills need to be assembled before technology development can proceed in an integrated manner, If one were to develop a process, expertise on plant engineering utilities, instrumentation/control by-product utilisation, environmental engineering and material science, are as necessary as the basic process capability itself. Similarly, for developing a product, one needs a thorough understanding of the state-of-the-art in components and materials fabrication techniques as also product evaluation techniques. Skills in production engineering, jigs and tools, value engineering and product styling are also necessary.

All skills needed for technology development should be close to hand; many should be in-house but some can be located nearby. It should, be recognised that certain types and levels of expertise will be often required so as to get the necessary objectivity or involvement. Hence extension of linkages from the core group developing the technology to other specialised groups (such as Universities, Test Centres, Standards Laboratories, Consultancy Agencies) should be planned and encouraged from the inception itself.

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Case material has been prepared to serve as a basis for class discussion Cases are not designed to present illustrations of either correct or incorrect handling of managerial problems.

Indigenous development of technology has several built-in advantages. Generally, the trained, competent manpower with the requisite mix of skills is available readily. Intra-institutional ties with their several benefits are easily set up. The product that is developed is more likely to fit in with the local culture than one for which the technology is imported. So, provided one avoids pitfalls such as sub-optimal effort, non-recognition of the product life-cycle, non-exposure to state-of-the-art, isolation from cross-fertilisation and non-establishment of needed linkages, technology development programme can be mounted successfully.

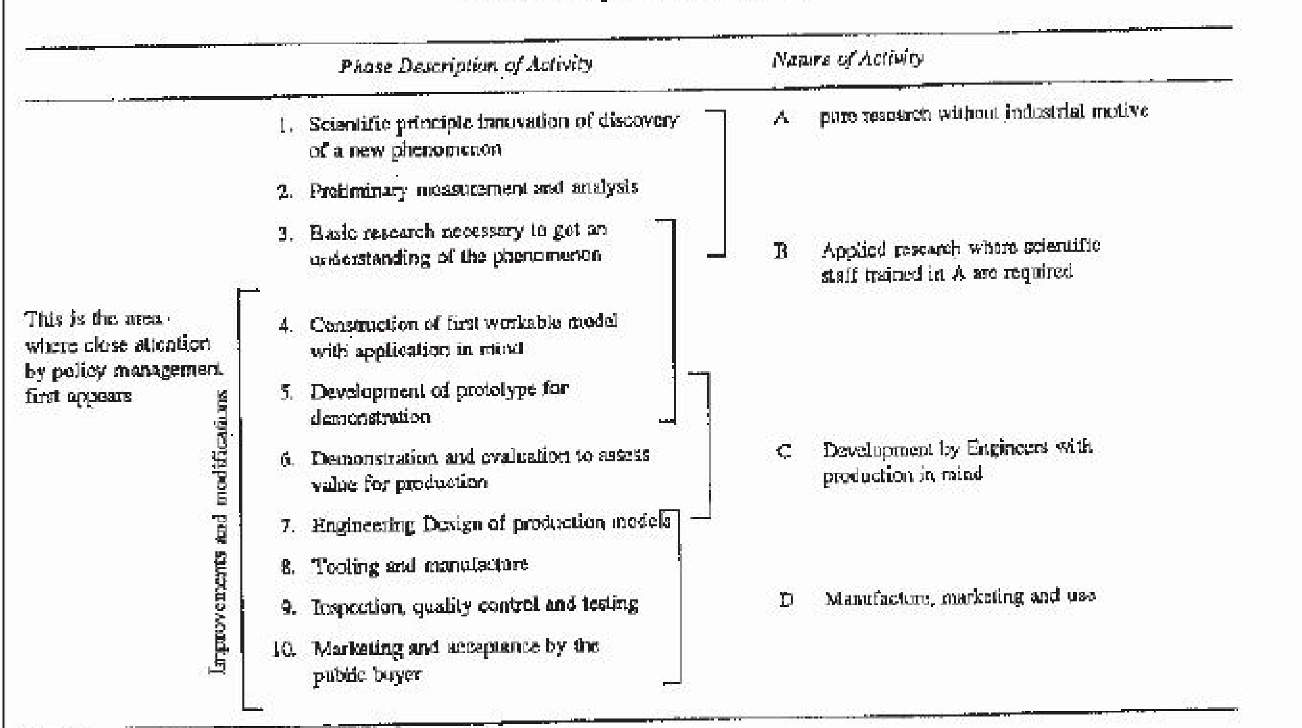
In the interest of reducing the development time or cost, or of lowering the risk, several options such as acquiring part of the technology from abroad or of contracting out a portion of the development can be considered as relevant to each case.

A few case histories given below illustrate CEL's experience in Technology Generation and Absorption and highlight the use of the overall strategy and general principles described above.

Ferrites-A Classical Innovation Chain

CEL is the largest producer in India of professional ferrites. The technology development took roughly a decade while product life is expected to be several decades. The laboratory and pilot plant scales of development for the ferrite-making-process were undertaken in the National Physical Laboratory (NPL)of CSIR during the early 70's. The personnel involved were then transferred to CEL, where they set up and operated a production facility, while carrying out development of newer ferrite materials, more ferrite products, more innovative applications of ferrites as well as investigation of alternative raw materials and cheaper production process. Agencies such as DST, DSIR DOE and NPL were actively involved throughout the programme so as to secure technical evaluation, marketing and other supporting inputs. As a result of this well orchestrated indigenous technology development programme spanning more than 10 years, a technology which was closely held even abroad has been developed and is in large-scale use in India. The innovation chain, going from invention to market testing to pilot production to supply so as to satisfy the market need as shown in Figure 1 has been fully traversed.

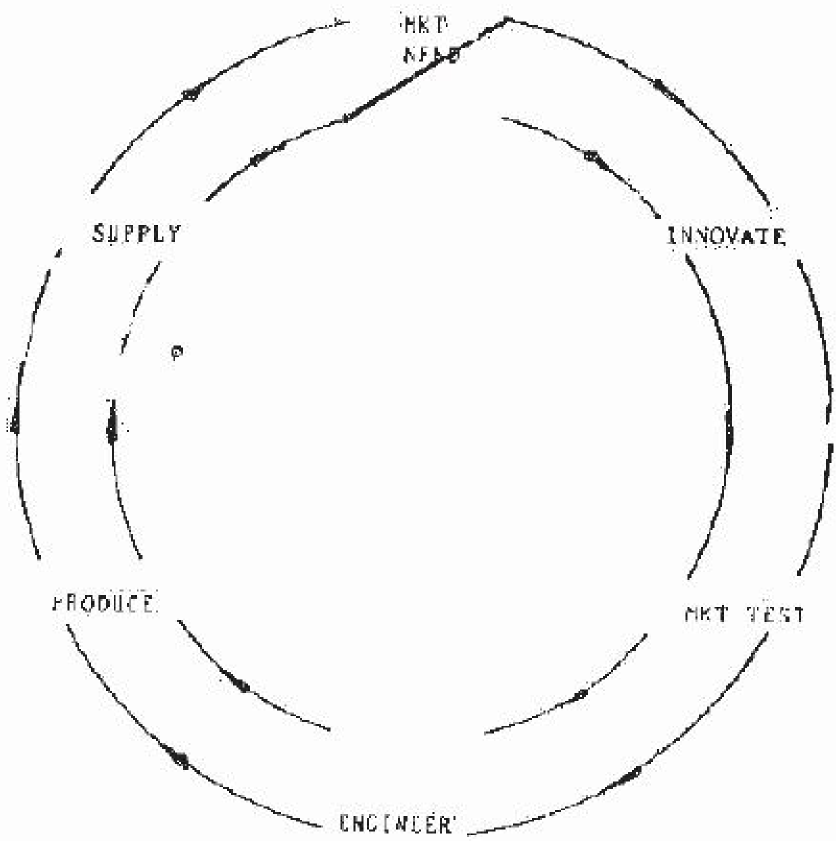
Figure 1: The Innovation Chain
Research Through Development to Use



Projection TV

In the case of a product with a short life-cycle no sooner has the innovation chain been traversed than the market requirements change somewhat and so it becomes necessary to go through the chain once again in order to make a more contemporary product. The innovation now- proceeds on a spiral as shown in Figure 2. The projection Television (PTV) system produced by CEL process. developed a black-andwhite PTV in the earl eighties, but found that it was not very relevant as colour telecasting had come into vogue. is a classical outcome o this early B eing aware of the market need which could not be satisfied in time by a further technology dovelopment on its own, CEL acquired PTV production technology in 1986 from a foreign source for a single model. The Company has since gone around the innovation spiral twice-once for fine tuning the product for the Indian Market and once again for developing a whole family of PTV, offering several sizes, modes of projection and grades of performance. As a result, CEL has now introduced two models one a High Resolution model ideally suited for Computer graphics projection and the other of 2 to 4.5 meters diagonal screen size meant for auditoria and video parlours.

Figure 2: Innovation Spiral



Colour TV Receiver

A colour TV set, developed; at CEERI, Pilani of CSIR in the early 80's was taken on by CEL for production. CEL found that the state-of-the-art for components had since changed and so had to redesign the set. Also the product had to be re-engineered to meet national specifications which had been notified by that time by the Department of Electronics. The anesthetics and ergonomics also had to be brought in with the market demand. Production engineering had to be carried out and production documentation created. These activities were all successfully compressed into a mere 18 months over 1985-86. Meanwhile, several companies had already entered the colour TV market and had established a substantial presence with; significant market shares. Hence, even though CEL had a very good product to market, the risks of entering the market at that late stage were considered unacceptable. Hence product launch on a large-scale for the metropolitan consumer market was aborted. However to meet the needs of small town and rural areas, CEL has developed a special type of colour television set of low power consumption powered by solar cells. Data sheet of this colour TV receiver the first of its kind in the country is given in Annexure I. This case history clearly shows the importance of product life-cycle in setting the R&D time targets.

Ferrite Phase Shifters

A strength of CEL was ability to formulate ferrite material capable of producing ferrites of almost any desired characteristics. Due to its excellent understanding of the material science involved, and its extensive practical experience, CEL had perfected this strength. The Company was also good at fabricating ferrites to intricate shapes and closely held tolerances. Using these strengths CEL was able to glean a very good opportunity to develop sophisticated microwave components for use in advanced Defence Radars. CEL had to team with several DRDO agencies and two IITs to achieve this goal. Due to the untiring and harmonious efforts of this multi-institutional team, another technology very closely held abroad even today, is available to us and volume production is to start shortly after successful pilot production.

Piezo Ceramics—Technology Blending

CEL had developed piezo-ceramics in the early 80's. It was hoping to find a large market for piezo-ceramic elements as ultrasonic transducers and gas lighters. However, these two markets did not materialise due to several market and commercial considerations and CEL had to be content with making only a small number of specialised assemblies for defence. In 1985, CEL saw an opportunity for the large-scale induction of piezo-ceramics as transducer elements in the electronic push-button telephones for the manufacture of which technology was being inducted from abroad. Though the telephone manufacturing technology was being distributed to several manufacturing agencies, DOE, the coordinating ministry chose CEL as the sole company for procuring from the foreign technology vendor mass manufacturing technology for the piezo-ceramic diaphragm which is used in both the transmitter and receiver capsules. This was done in view of CEL's longstanding experience in this specialised area. Thereupon, CEL entered into an excellent technology transfer agreement but simultaneously also developed on its own, a similar technology on a pilot plant scale. This hands-on approach has certainly enabled the foreign collaborator to appreciate CEL's strength and for CEL to better negotiate and then start absorbing the technology. As a result, discussions between both parties has been based on mutual respect and the technology transfer is proceeding smoothly, leading to hitch-free mass production a difficult, high technology item. This case proves that there are occasions when a judicious blend of locally developed and foreign technology can be particularly effective.

Railway Electronics

There are several end-users, who over the years, have developed the expertise to forecast the type of products to meet their future needs. One such agency is our Railways. For ensuring the safety of passengers and rolling stock, the Indian Railways wished to induct certain sophisticated electronic equipment called Axle Counters. CEL had good production expertise for this class of equipment. The Research Design and Standards Organisation (RDSO) of the Railways possessed specialised expertise regarding the design and proving out methodology for equipment which will always attain safe states on failure as in the case of Railway safety Equipment. IIT, Delhi had an excellent design team capable of designing modern digital signal processing equipment. To address the new opportunity which the proposed induction of Axle Counters offered, CEL felt that it was best to adopt a team approach along with RDSO and IIT. Accordingly, a team of engineers from CEL were posted at IIT in 1983 and the IIT/CEL team undertook joint design, development and prototyping activity. The availability of design and product engineering/industrial prototyping skills at one location facilitated the paralleling of several activities which otherwise would have had to be undertaken in serial orders thereby resulting in extending the total R&D time involved. The on-line availability of RDSO to critically comment and evaluate the design at all stages enabled several quick iterations of the design to be made and prototyping which was fully completed to Railway specifications in a matter of only 18 months. The close involvement of Railway Board, DOE, DST & DSIR ensured all the support that was needed. The product so developed has since been successfully mass manufactured by CEL and extensively deployed by the Railways. Most importantly, it has performed fully according to expectations. Encouraged by this success, development of technology for the next generation of Axle Counters was structured on a similar basis with CEL, IIT & RDSO as partners, even as the first generation design went into volume production. Several other electronic railway signalling and safety systems have also been developed on the same basis.

Picture Tube Phosphor: A Quest for the Right Linkages

NPL of CSIR had developed a bench scale process for making TV picture tube phosphor. NPL lincensed this technology to a small-scale entrepreneur, who could not set up a manufacturing plant due to the complexities involved in up-scaling. Meanwhile, certain rationalisations were made by the Government on the import duty on TV picture type phosphor, which rendered the indigenous project economics unviable. So, though product made with laboratory grade chemicals at NPL on a laboratory scale was found to be satisfactory by one user, NFL was not pursing taking the process to commercial fruition.

OP,L, which was trying to expand its product portfolio, was interested in the production of picture tube phosphor. ,fr studied the process adopted by NPL, which required scaling up by a factor of 100 *for* commercial production.: CEL concluded that, if commercial grade chemicals could be used and the purity of the phosphor still maintained, the project's techno-commercial viability could be assured. It also noticed that meanwhile other picture tube manufacturers than the one which found the NPL product acceptable, had come on the scene. At this stage, other more attractive investment opportunities became available to CEL and hence, at the instance of DSIR, NRDC came in to ensure further development of the phosphor technology and retained CEL for technical consultance.

Engineers India Limited was also brought in for process development, up-scaling and engineering. With CEL & EIL backing the technology development NPL was asked to restart its process development using commercial 4ather than laboratory grade raw materials, procured in bulk by CEL. The process was fine-tuned to ensure production of satisfactory phosphor, and the phosphor produced was tried out by leading TV picture tube manufacturers and found satisfactory.

While EIL engineered the up-scaled process, it was found that the viability of the process critically depended on selecting and sizing certain key furnaces. CEL, which had considerable expertise in this type of line because of its heavy involvement in black ceramics (ferriies) and white ceramics (piezo-ceramics & alumina), was able:, to perform this specialized task.

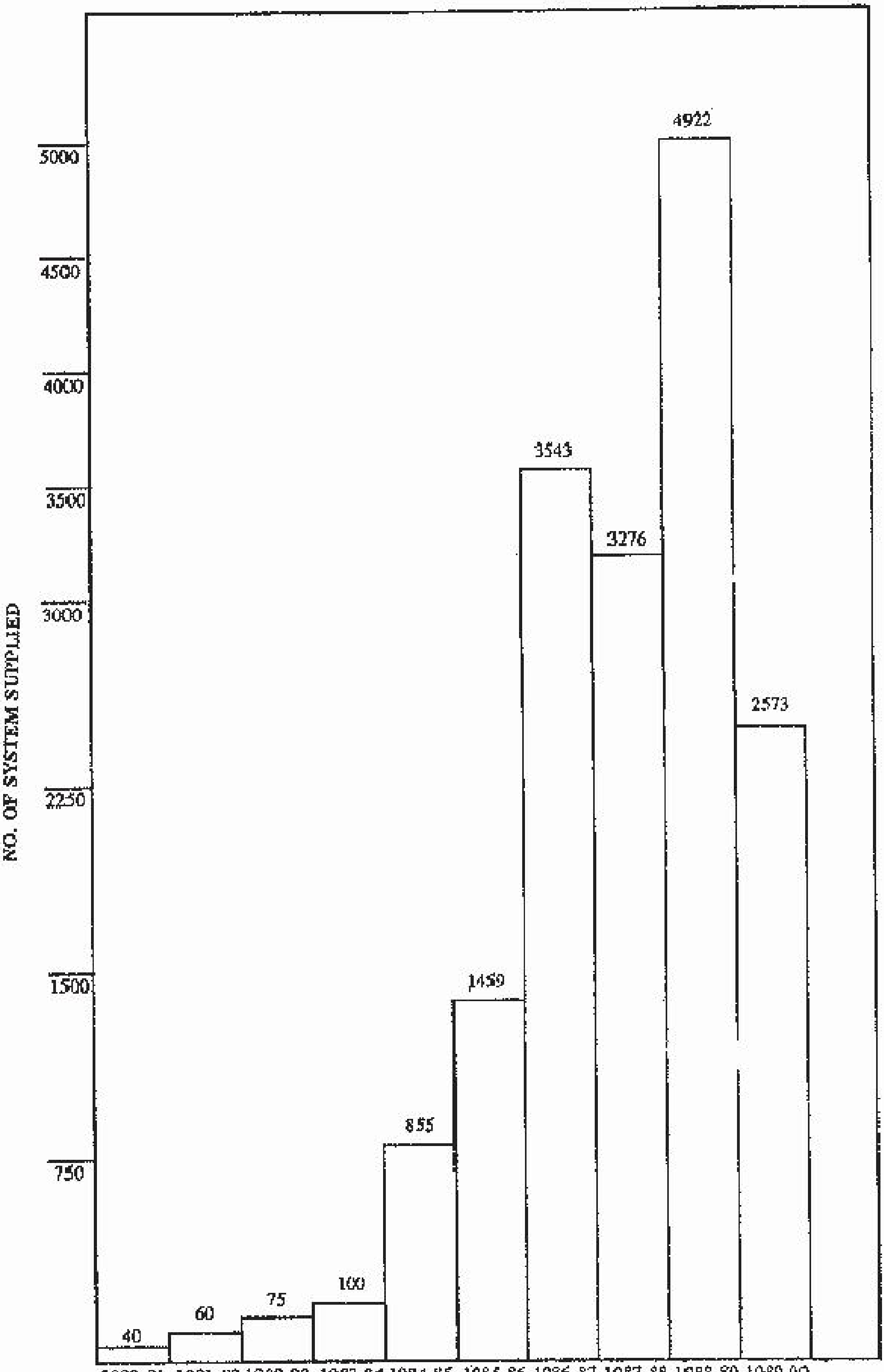
The upshot of the exercise was a thorougly revamped, professionally documented, known-to-be-viable process, with the customers fully conditioned to accept the end product. As a result NRDC has been able to license this technology to set up a 60 tons/annum plant which is to come up in the clean environment of Himachal Pradesh.

Solar Photovoltaics: A Leading Edge Technology

Perception of opportunity at the earliest, and tenacious pursuit of the opportunity by an integrated clear-cut programme of technology development/absorption are necessary, but not sufficient for commercial success. As in the case of competitive sport, timing is also an equally vital ingredient. CEL's experience of over a decade in Solar Photovoltaic (SPV) Energy Systems illustrates how an opportunity perceived well ahead of time' gave shape to a large, concerted technology development programme. It also shows how, by timing the key events carefully, CEL has been able to achieve the position of the world's fourth largest SPV company, with strength in materials, cells and modules production, systems design, supply of systems and field support of products in the, field, all on a fully vertically integrated basis.

During the late 70's, CEL and its then administrative ministry, DST, saw that Solar Photovoltaics Energy was likely to be a sophisticated technology-the development and mastering of which would be immensely useful for our country, with its enormous need for energy in rural and remote areas. While the fabrication of the primary energy conversion device, viz., the solar cell is essentially a semiconductor process, the interconnection of cells into usable modules (called encapsulation technology), the design and manufacture of SPV systems, which tend to be location and load-specific require several types' of systems-engineering and product manufacturing technology. The installation, maintenance and other product support activities need field engineering expertise.

While the types of skills needed for successful development of SPV technology were clearly seen, it was obvious that almost all of them were not readily available and would have to be developed and honed from scratch without getting bogged down by the magnitude and complexity of the job. Encouraged by tile exciting long-term vision of such a goal, CEL mounted a comprehensive skill building and technology development programme. The programme was closely supported by DST and by the Department of Non-conventional Energy Sources (DNES) which was spun-off from DST, DNES made CEL the implementing agency for the National Solar Photovoltaic Energy Demonstration (NASPED) Programme. The newly constituted DSIR, which became CEL's administrative ministry in early 1985 provided every possible input and monitored the progress regularly. The administrative Ministry also gave concrete demonstration of its commitment to CEL's SPV programme by sanctioning CEL's major project to set up a plant with an ultimate production capacity of 5 MW of solar cells per year at a time the entire world's production was of the order of 10 MW per year.


NO. OF SYSTEM SUPPLIED
5000
4500
4000
3500
3000
2250
1500
750
40
60
75
100
855
1459
3543
3276
4922
2573
1980-81
1981-82
1982-83
1983-84
1984-85
1985-86
1986-87
1987-88
1988-89
1989-90

CEL realised that in a frontier technology, several aspects normally kept separate, had to be closely intertwined. Typically, process innovation in cell technology, the actual manufacturing of SPV cells, the up-scaling of plant capacity, and development of special manufacturing machinery, had to be dealt with as a composite whole and not as different entities. The manufacturing process for cells was therefore virtually developed on the production levels themselves wholly in an industrial environment and on a large-scale. The product technology developed in-house had to be evaluated in the field before the product could be put into volume production. CEL has gone through several generations of the cell manufacturing process over the last 6 years. It has a 2 MWp facility churning out SPV products to international standards. Approximately, 17,000 CEL-made SPV systems for covering some 35 different types of applications and rural and industrial applications are at work allover India and in quite a few other developing countries. Figure 3 indicates the total No. of SPV systems made and sold during each year of the 7th Plan. In the International Solar Photovoltaic market place. CEL has carved out a leadership position for itself by simultaneous development of skills, process and products, by massive, well-focussed long-term programmes and by careful : timing of its activities. Recognising that in such frontier technologies, the linkages need to be international than national, CEL has established links and collaborative programmes with numerous agencies both at home and abroad.

Table 1 illustrates the range and diversity of CEL's SPV systems. They have all exploited a mix of modern technologies through innovative design, and achieved objective not feasible by other technologies within economic cost.

1. Table 1 Applications of CEL made Solar Photovoltaic and Systems

1 Unmanned Off-Shore Oil Platforms
2 Catholic Protection of Oil and Other Pipelines
3 Fossil-Fuel Dispensing Station
4 Hydro-Meteorological Stations
5 Data Collection Platforms
6 Very Low Power Television Transmitters
7 Direct Reception Television Sets
8 Black & White and Colour Television Receivers
9 Public Address Systems
10 Transistorised Radio Receivers
11 Telecommunication and Telemetry
12 Battery Changing
13 Defense Applications
14 Applications by Paramilitary Forces
15 Powering of Electronics on Lighthouses
16 Railway Platform Lighting and Panel Interlocking
17 Warning Signal for Unmanned Railway Level-Crossings
18 Applications in Antarctica
19 Application in the Mount Everest Expedition
20 Village Electrification
21 Water Pumping for Irrigation
22 Water Pumping for Drinking Water Supply
23 Water Purification System
24 Deep Well Water Pumping
25 Village Street Lighting
26 Domestic and Community Lighting
27 Medical Refrigeration
28 Power for Transportation
29 Electric Fencing
30 Burglar Alarm
31 Solar Clock

Solagard

As discussed earlier CEL had been operatingextensivly both in Railway Electronics and in Solar Photovoltaics. It was therefore, but natural for CEL to see if, by combination of the technologies involved, new products could be developed in the service of its clientele.
A systematic review of the requirements of the Railways revealed that there existed the need for a rugged

automatic stand alone system that would warn road users of the impending arrival of trains at some, 9400 level crossings in our country. CEL, therefore, launched on the development of a product to "guard level crossings". It harnessed digital signal processing, modern VHF radio and SPY technologies to produce an innovative product which is patented and trademarked as SOLAGARD. With intensive, on-line support from several Railway Agencies, the product was designed, proven out and engineered for bulk production, all in matter of 2 years. By being dive to all prospects of cross-fertilization CEL has been able to innovate a brand-new product, to fill a long-standing need and chalk up a world first in innovation.

Summing up

With a technology strategy of the kind indicated above, CEL has been able to increase its turnover from Rs. 2.75 crores in 1984-85 to around Rs. 26 crores in 1989-90. Around 90% of that turnover in 1989-90 has been based on indigenous technology of one type or another which has been made possible because of a sustained high level R&D investment. Using such a base as a launch pad, CEL has kept a turnover target of 70 crores in the last year of 8th plan period with steep increases in output of all its product lines.

Questions

1 How would you describe the technology strategy of CEL? What features do you observe in the company's technology strategy?

2 What have been the benefits to the company from the technology approach that it, has followed?

3 Take the case histories one by one and indicate the managerial lessons/conclusions that can be drawn from each case history.

4 What do you count as the strengths of the Company?

5 The case history "Colour, T.V. Receiver" talks about product life cycle. Describe the various phases of product life cycle and show them graphically. At what stage of the cycle, you think, R&D time targets should be set and at what stage the new products should be ready for launch? Was there a mismatch between R&D time targets and new product launched in this particular case.

Figure 3 :

BRIEF GENERAL DESCRIPTION :

CEL DC powered Colour TV is optimally custom designed for Photovoltaic applications. It operates on 24 V batteries and consumes a mere 40 watts of power. Low power consumption has been achieved by judicious selection of components and use of a super efficient DC to DC convertor for powering the various circuits.

Plug-in modular concept for electronic modules has been adopted for ease of servicing, an important requirement for such remotely installed CTVs. State-of-the-art components have been used for excellent performance and high reliability.

SOLAR C.T.V. SPECIFICATION

1. Screen Size	: 51 Cms
2. Colour Receiving system	: CCIR PAL System B&G
3. Receiving channels	: VHF : 2-12 : UHF : 21 to 69
	: 8 Soft Push-buttons for presetting the channels and bands.
	: 2 W music power

CASE 2

EICHER TRACTORS INDIA LIMITED

Historical Background

Eicher Tractors India Limited was floated in 1959 by the Goodearth Company. The latter had been engaged in the business of selling imported tractors. In 1948, Mr. M.M. Lai, the founder of the company had taken up the dealership of Ferguson tractors for a few districts each in Western U.P. and the areas now in Haryana. Tractors at that time had a "curiosity value" and a market had to be developed for a large-scale business. Mr. Lai found the tractor distributorship to be profitable and in 1952 he decided to import tractors on his own.

In 1952, the Goodearth Company imported a few tractors from Gobr. Eicher of West German to "test market" them. The market response was good and from 1953 onwards the company imported these tractors in large quantities. The imports in those early years were in the range of 100 to 200 a year. It never went beyond 300 a year. A good workshop was set up for repairs and maintenance, and training of farmers and mechanics. Import of complete tractors went on till the end of 1956 after which the liberal import of tractors through normal trade channels ended on account of stringent foreign exchange situation. Around this time Mr. M.M. Lal started considering manufacture of tractors in India. Around 1957-58 he went over to West Germany to explore the possibilities of a collaboration with Gebr. Eicher, for the manufacture of tractors to their design and specifications. Simultaneously he applied to the Government of India for an industrial licence. Towards the end of 1958 the Government issued an industrial licence for the manufacture of tractors.

Product

At the time Mr. M.M. Lal started considering the import of tractors, most agriculturists in the country depended upon "human" and "animal" power. Indian farmers had not been exposed to mechanization of agricultural operations, and were, therefore, apt to put the tractor to abuse. There were almost no facilities for maintenance of tractors. The level of technical skill possessed by the farmer was very low. Mr. Lal realised that a tractor was required which could withstand various types of use and abuse like pushing heavy loads, pulling traitors, various farm operations, etc. Ease of maintenance even with poorly trained village mechanics, low price and low operating costs were major characteristics, which Mr. Lal looked for in his extensive tour of Europe for a suitable tractor. The Eicher tractor fulfilled these requirements, It was rugged in design, it could be easily maintained by farmers with a low level of technical skill and was low priced. In fact till recently the Eicher Tractor was the lowest priced one in the country.

The tractor was powered by a single cylinder air cooled engine and had a minimum number of moving parts. It did not have a hydraulic system for implement control, whereas by 1960s almost all tractors in the developed countries had incorporated this in their designs. In other words, the tractor model selected for manufacture in India was comparatively an obsolete model. The Tariff Commission reported:

> *The tractor manufactured by the Indian company is based on the drawings and technical specifications of its West German collaborators and is comparable with a similar model of farm tractor which the German firm was formerly manufacturing. It may, however be noted that the German collaborators are no longer manufacturing tractors of specifications adopted since they have brought out multi-cylinder and more sophisticated tractors for German market, which do not bear any comparison with the erstwhile German model and the present Indian one.*

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* The case (1988) has been written by Prof. Shekhar Chaudhuri (UM, Ahmedabad. Used with permission. Case material of the Indian Institute of Management, Ahmedabad, is prepared as a basis for class discussion. Cases are not designed to present illustration of either correct or incorrect handling of administrative problems.

Foreign Collaboration

Gebr. Eicher of West German started its a small venture just after World War II. It had a very low production volume of about 3000 tractors per annum. Because of the simplicity of design and low production volume, the machinery used were mostly general purpose type and less sophisticated. The manufacturing technology used by them was compatible with the level of technological skills available in the automobile ancillary industry in India and their production volume matched Eicher India's licensed capacity of 20(X) tractors per annum.

A collaboration agreement was signed in 1959, which ended in April 1973. It was a financial-cum-technical collaboration, the collaborators were given a share in the share capital of the company and the right to nominate two of their representatives on the Board of Directors. According to the agreement, Gebr. Eicher of West Germany was required to, i) supply the documents and drawings for the manufacture and assembly of tractors, ii) supply critical components till they were progressively indigenized, ill) help in establishing production and assembly operations in India, iv) supply all drawings and documentation of jigs, fixtures, and v) train engineers of Eicher India at their works.

A royalty of 2 per cent was payable on ex-works cost of components manufactured in India. Another 2 per cent was payable as technical know-how fee.

The German collaborators sent a few technicians to the Indian company during the initial years to help in setting up the assembly operations. However, before much progress could be achieved in setting up the operation, the collaborator ran into a number of problems. According to Mr. Vikram Lai, the present Managing Director:

> ... in the 1960s, Gebr. Eicher were on a downward trend --sinking market share - inadequate technology they could not put any money into development of new products. In 1970 Gebr. Eicher was bought over by Massey Ferguson of Canada. Our collaboration continued from 1959 to 1973.... However, the collaboration was not very satisfactory as both were beset with problems. Ours was production, import licence availability, finance, etc. Theirs was basically marketing. They gave us the drawings and documentation and also were prepared to train our engineers at their works, But, because of lack of funds we could manage to send only 3 persons for a few weeks only. During the initial stages pilot components used to be sent to Gebr. Eicher for testing. Now we are supplying them some components, which have been commended by our collaborators for their quality.

Manufacturing Programme

PLANT CAPACITY

Initially the Government had issued an industrial licence to Eicher Tractors India Ltd. for manufacturing 1250 tractors per annum, which was later on increased to 2(X)0 tractors per annum. Compared to the average production capacities of over 30,000 tractors per annum of major manufacturers in America and Europe, Eicher Tractor India's licensed capacity was very small. But because of difficulty in getting import licences for CKD packs and their lack of technical and managerial expertise, the production volume never went beyond 2(X) tractors per annum for the first few years.

PHASED INDIGENIZATION

The company started production on 3rd September, 1960. The manufacturing programme as approved by the Government envisaged the following progressive indigenization:

Year	Indigenous content
1st	48.6%
2nd	79.5%
3rd	100.0%

Implementation of this rapid indigenization programme was, however, fraught with numerous difficulties.

The balance-of payment situation of India had started deteriorating in the late fifties. Simultaneously, Government ended the liberal import facilities to conserve foreign exchange. This had serious repercussions on the operations of Eicher Tractors India Ltd. In the word of Mr. Vikram Lai:

> *The production was limited to a very few items. A situation of crisis continued for the next few years. It was a situation of living from hand to mouth. Foreign exchange was not available. The Government allowed CKD packs for 150-200 tractors a year and this production level went on for six years.*
>
> *Neither my father nor the collaborators had understood that foreign exchange availability would be such a problem. He thought that as the industrial licence was for 1250 tractors/year, import of CKD packs would be available to that extent. Eicher (Germany) had specially produced 1250 almost complete tractors for us, but those had to be kept in stock in Germany as we did not have the licence to import them. The collaborator's financial position was upset by this....*
>
> *We did not have the proper infrastructure required for the challenging task of indigenization as stipulated by government. The infrastructure required was in terms of proper and adequate engineering staff, tool room facilities, purchasing and vendor development staff etc. All these functions in the company were skeletal in nature. The low production volume, because of the small import licences, could not sustain a larger personnel strength required for the rapid indigenization programme....*
>
> *On continuous representation to Government, we were finally given an import licence for 1200 CKD packs.... In a period of 3 to 4 years losses kept on accumulating and if depreciation had been provided the total accumulated losses in 1969-70 was double the paid up capital.*
>
> *In the words of the Production Manager:*
>
> *In the first phase most of the simple sheet metal components were indigenized. These were the mudguards, bonnet, fuel tank etc. The engine coupled with the transmission used to be directly imported from the collaborators' works. Also along with these some of the complicated items like mud-guard tops which required a sophisticated die used to be imported. This phase lasted until 1964. During this time we set up the fabrication shop and the tractor assembly shop.*

In 1966 the Government liberalised the import policy and import licences of CIF value of Rs. 51.47 lakhs for the import of essential raw materials and, components were issued. Another import licence of the value of Rs. 38.89 lakhs, was expected.

During 1967-68 machines worth Rs. 16.75 lakhs were installed to achieve indigenization of the tractor. They calculated the break-even point at about 500 tractors per year. The target for 1968-69 was fixed at 5(K) tractors.

In 1968 Government granted another import licence for Rs. 49 lakhs for the import of special steels, tools and components.

In the third phase the development of the engine was taken up starting with simpler parts like connecting rod, crank shaft, and then finally engine housing. By 1969-70 the whole of the engine had been indigenized and only the transmission remained.

Around 1970-71 some Indian companies started manufacturing gears. Efforts for indigenously manufacturing all the gears began and by around 1974-75 the company was successful in developing reliable sources for the same. An R&D cell specially for concentrating on developmental activities was created through which technical help was given to the gear manufacturers. A part of the suppliers' developmental expenses was also met by the company. Gears were completely indigenized by 1974-75.

Sources of Funds

According to the Managing Director of the company:

Our share capital was extremely small.... Another complication in the tractor industry was that prices and distribution was controlled. We were always extremely short of cash. The company would not have survived had it not been for the enormous goodwill it had with the dealers. We took advances from the dealers - these were called security advances. That is a certain sum of money -- about Rs. 4000 per tractor - was taken from a dealer for a period of 1 year in advance of delivery of tractor.. Prices of tractors had .been maintained in those days at an artificially low level. This had the implication that we had constant cash problems. I do not remember a single day on which we did not have problems of either paying salaries, wages, government dues or creditors etc,

The following table shows the major sources of funds for different years:

Table 1

(Rs. lakhs)

Details	1964	1965	1967	1970	1977
Share capital					
Authorised	25.00	100.00	100.00	100.00	100.00
Issued and subscribed	6.62	6.81	14.72	19.16	19.17
Secured loans	9.30	11.70	42.77	27.30	82.88
Unsecured loans	10.76	7.29	7.01	8.86	
Current liabilities	26.26	13.64	39.39	57.04	255.70
Reserves and surplus	1.74	1.60	2.08	2.08	94.47

Source : Annual reports

Plant and Machinery

One of the major tasks for Mr. Vikram Lal after he joined Eicher Tractors India Ltd. in 1968 was the selection of proper plant and machinery to increase production, which had remained extremely low for the past 8 years (Table 2).

Table 2

Production (July - June) (26.5 h.p.)

Year	Nos.
1960-61	132
1961-62	149
1962-63	214
1963-64	64
1964-65	225
1965-66	123
1966-67	92
1967-68	204
1968-69	346
1969-70	378
1970-71	859
1971-72	789
1972-73	854
1973-74	1081

1974-75	1232
1975-76	2142
1976-77	2719

Technically, there were three options in the choice of manufacturing technology:

1. Use of mass production technology using special purpose machines for all operations.
2. Use of only general purpose or universal machinery for all operations.
3. Use of combination of special purpose and universal machinery.

The first choice was immediately out of the picture as there were not enough funds to employ mass production technology and also the fact that at production volumes of 100 or 200 or even 300 tractors per year it would not have been economically justifiable.

Use of universal machinery exclusively was possible but the skill level required in certain operations would be very high and reliability of quality would be a problem. So the management considered the use of a composite technology,. i.e., a combination of universal and special purpose machinery, to be a judicious solution.

A major factor that influenced the choice of plant and machinery was the acute paucity of funds, which was responsible for the evolution of a corporate philosophy of "low cost" in every endeavour. To overcome the problem of financial stringency, the management decided to purchase some second hand machinery from the collaborator which was available at very low cost. These machines were required for some of the critical operations, e.g. machining of connecting rod, cam shaft, etc.

Indigenous machinery available from, well-known manufacturers like HMT or Kirloskar were too expensive which Eicher Tractors (India) could not afford. So a team of engineers along with the present managing director went around small-scale enterprises in Punjab to observe the machines and equipments they utilized. After studying their practices thoroughly the management decided to go ahead with purchase of very simple machines called Addas manufactured by the small-scale industry in Ludhiana and Batala in Punjab: These machines are basically the skeleton cast iron base of the lathos, drilling machines or milling machines fitted with very simple tool carrying heads. These Addas are basically universal machinery which can be tooled up for mass production of different item$, The idea of the management was to design and manufacture proper jigs and fixtures by which the reliability of the operations could be enhanced. By this method the operations could be "de-skilled" to a certain extent.

The layout of the shop was designed in such a way that each component could be manufactured in a part of the shop, using a combination of these Addas. Using a combination of process and product line layout for certain critical components it was possible to increase the capacity of production with low capital expenditure in plant and machinery. The Addas cost them approximately Rs, 3000 and the special jigs and fixtures another Rs. 1000. The total cost of each Addas was Rs. 4000 whereas a machine from the established large machine tool manufacturer would have cost them Rs. 20000-50000. Capital expenditure on fixed assets is as shown in Table 3.

Table 3

Fixed Assets (its. lakhs)

(at cost less depreciation)

Year	Value
1964	6.86
1965	19.82
1970;	26.58
1976*	105,99
1977	154.95

* in 1976, land accounted for, Rs. 4.0 lakhs, buildings Rs. 11.0 lakhs, and plant and machinery 71.3 lakhs after depreciation. Break-up for the other years was net readily available.

Source : Annual Reports.

A separate engineering team was created to cater to such needs as converting very simple universal machinery to single purpose machine by designing proper jigs and fixtures, copying attachments, hydraulic systems, etc. Also many of the complicated machinery were designed and manufactured in the company by a specially created cell. Machines like Dynamic Balancing Machine for balancing the crank shaft and the flywheel; Fine Boring and Lapping Machine for the cylinder head were designed and manufactured by the company's engineers.

The present managing director's philosophy has always been to economize on capital expenditures as expressed by the following quotation:

> *... why don't we acquire highly sophisticated equipment at every plant and add the usual frills like most large companies do? .... We did not wish to invest heavily in fixed assets, because we felt that we could not afford to do so without raising our prices. What originally started as a reasoning born out of paucity of funds has now become a philosophy of the company - the low cost approach in every endeavour. This is also in keeping with the needs of our country's developing economy where capital is scarce and therefore must be conserved.*

This philosophy continues even now, though the company has long turned the corner and is making handsome profits. To quote one example, the company plans to make a pressurised paint booth at a cost of approximately Rs, 8 lakhs, which if purchased from established manufacturers would cost them Rs. 16 lakhs. The new plant for the 35 h.p. tractor and the gear manufacturing which the company is putting up at Parwanoo will follow the same philosophy. They plan to purchase Addas of better quality which would give them higher reliability.

However, in the R&D department, their policy is to have sophisticated machines and their total investment in the R&D department is several times that in the production plant. Till recently the policy of the management was to subcontract as many items as possible to reduce the capital expenditure. This was possible till the production volume was quite low at around 2500-3000 tractors per annum. With increase in volume the management feels that the sensitivity of the manufacturing operations to supplier linkages becomes too critical and therefore to insulate themselves from such uncertainties they are in the process of creating some manufacturing base in the company for certain critical components. This, the management, feels will also act as a deferent against price increases by suppliers. The gear and transmission plant which is coming up at Parwanoo is part of such a policy. The engine plant at Alwar, was started to cater to the increasing volume and also to cater to the needs of other industries.

A machine tool manufacturing unit has been started to cater to the needs of machinery for the three plants at Faridabad, Alwar and Parwanoo. This machine tool unit had its genesis in the early period of the Faridabad plant when a special cell was created to convert all the universal machinery into single purpose machinery to make modifications on the machinery bought from the collaborator, and design and manufacture machinery for replacement purposes. The Addas used by the company have a usable life of about 3 to 5 years.

The manufacturing policies of the company are expressed in the following statements of the managing director:

> *We do not have any foundry or forgeshops --we buy all castings and forged items, though circumstances may force us to take up such activities also.*
>
> *We make half a dozen major components of the engine -- crank case, cam shaft, connecting rod, cylinder head and cylinder liner.*
>
> *In all these critical components we buy the forgings or castings and machine them.*
>
> *In the transmission system we make very little -- we mainly do the finishing operations. Some other critical components which we make ourselves are the steering worm and the shifter forks. A special purpose machine is required for the manufacture of the steering worm, which is made by ourselves.*
>
> *The shifter fork is a little complicated component, for which we were not able to develop reliable subcontractors.*

We buy all the gears and shafts from established manufacturers. We have about half a dozen sources.

We had a sheet metal and fabrication shop-where we were manufacturing the bonnet, front axle, and threat point linkage and some other small components. We have now decided to discontinue the fabrication shop and are going to gradually subcontract these items. Facilities for fabrication and sheet metal work require very large space and also ample capacity is available outside.

At the same time we feel that we have come to a stage which is beyond the optimum limit of subcontracting which is one of the reasons for meting the gear and transmission plant at Parwanoo. Economics is not always the deciding factor. Securing safety in the supply of materials is necessary. Our basic machine shop has not changed since 1970-71-only last year we bought some equipment to replace some of the old.

Regarding the plant our thinking is that we will have some gear manufacturing capacity to fall back upon in times of crisis. The main activity would be manufacture of gears. We do not have any gear manufacturing capacity at present. At Parwanoo we are also going to have machining facilities for complicated transmission housings. Earlier we used to manufacture the housings. But later we got vendors to manufacture them, to whom we had advanced money for investing in machines, which we have recovered over a period of time.

Some observations made by him regarding choice of manufacturing technology are:

In India, and specially in the engineering industry, equipment selection is often done on the basis of non economic factors. In other words a production manager would be very happy to tell his friends that he has the most sophisticated machinery. He takes pride in the sophistication of the manufacturing processes employed by him. Often this takes precedence over economic considerations....

Many a time, machinery selection is accepted without investigation. Truisms like "SPMs are more economical than GPMs at large volumes of production, are simply imported from the West without considering the differences between the situation there and the underdeveloped countries.

Research and. Development

Developmental activities were undertaken from the very beginning of the company. A design cell had been created for undertaking the following activities:

1. Indigenization of all the tractor components.
2. Converting the simple Addas into single purpose machines by designing suitable jigs, fixtures and other special tooling.
3. Designing and manufacturing special purpose machines required for machining critical components.

Till about 1972-73 the whole organization was geared up to increase production. Prices being controlled by the Government the only other way of generating larger surpluses was through a larger volume. By 1970 the accumulated losses after providing depreciation amounted to Rs. 35.24 lakhs. However, by constantly increasing production, all the accumulated losses were wiped off by 1973-74.

During this period i.e. from 1959 to 1973-74 the financial position of the company had been very precarious and therefore no real efforts at R&D had been made.

Competition and Diversification

Also the tractor industry had been in a sellers' market till about 1972-73. According to the Managing Director, "marketing" as a concept had not taken roots in the company during this time. It could be described more as "distribution". Initially distribution of tractors also had been controlled by Government as the indigenous production was very small.

However, in 1972 the market started showing signs of a change. The Directors' Report in the Annual Report 0911-72) said:

> There is now tough competition in the Tractor market. Further, overall demand for tractors has fallen because of various reasons, such as further reduction in size of landholdings.

....On the recommendations of the Bureau, prices of all the indigenous tractors were revised in January February this year. The price for Eicher tractors was fixed at Rs. 25,200.... The company had however kept the sealing price at Rs. 23,700 ... in order to meet competition.

In order to give more incentive to the dealers and to enable them to improve their servicing facilities, the company raised the discount to its dealers from Rs. 800 to Rs. 1300 per tractor.

In 1973 the company added the following products to their product line:

1. Eicher Diesel Generating sets
2. Stationary Diesel Engines
3. Trailers 3-6 tons

No industrial licence was required for manufacturing and selling these new products.

The company's policy which guides new product decisions may be gauged from the following:

... the company has maintained its prime objective of economy with quality by providing sound low cost products. So much so that when the price control was lifted from the tractor industry in 1974, Eicher was the only organisation which did not raise its price, even marginally.

Yet another unit was set up in 1978. The product chosen was machine tools, which we felt could fill the gap existing in the market between the high cost/high precision machines made by large manufacturers and the low/cost precision machines manufactured by the small scale units...

The year 1973 also saw some exploratory steps in developing an export market for their products - mainly tractors. The company made efforts to develop markets in the developing countries of South America and Sudan. They also supplied samples of components for "Eicher" engines to their collaborators. The collaborators' report read as follows:

We are very glad to be able to say that this component just could not be better. All measurements are not only within tolerance but they are very close to the basic data.

In 1974-75 the financial position of the company was very bright, with a net profit of Rs. 38.6 lakhs (sec Exhibit 1). The company started giving its attention to areas like diversifying its tractor line, improving the existing tractor by providing automatic depth control systems and making improvements in the following areas:

1. Improved bonnet
2. Rigid Axle with improved suspension
3. Improvement in electrical system
4. Improved quality for better look and greater durability,

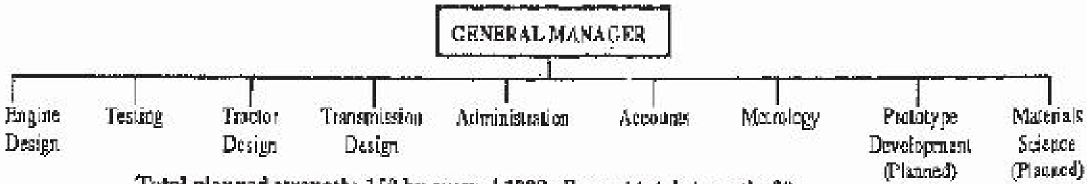
Till 1974-75 there were no separate facilities for developmental work and existing production facilities were used. In view of the enlarged activities envisaged for the R&D department the company approached the Indian Overseas Bank for loan facilities.

R&D Organization

In 1975-76 the company, for the first time, invested heavily in equipment and machinery for research and development. A beginning was made in the recruitment of personnel for manning the R&D department.

Dr. S. Satyamurthy, with 16 years experience in industrial research in Germany and $3^1/_2$ years experience in R&D management in TELCO joined the company as General Manager - Research and Development, The organization structure of R&D is shown on next page.

Figure I: Research & Development



Total planned strength: 150 by around 1980 , Present total strength: 90

The department is staffed by highly qualified personnel. Two of the senior managers including the chief of R&D hold Ph.D. degrees in their fields of specialization. The company has a policy of recruiting generally M.Tech. degree holders with experience in research and development as section heads and either M.Tech. or B.Tech. as Senior Engineers or Engineers below the section heads.

R&D Objectives

The present objective of the R&D department is to make constant improvements in the products, develop the 35 h.p. tractor, make improvements in the existing model in response to feedback from the field and cost reduction by making design changes.

A value analysis cell is planned to be created at a later stage which would look into aspects of providing the customer the value in the product at the least cost. Some attention is given to these aspects at present, but the management feels that it is inadequate. A systematic effort in value analysis would be very useful in cost reduction.

R&D Capital Expenditure

Systematic budgeting in the company is a very recent phenomenon. An annual budget is prepared by R&D, but their management is thinking of introducing "project costing" in R&D, and thinking of considering R&D department as a profit centre.

The capital expenditure on R&D is given below:

Year	Amount in lakhs
1977-78	85.30
1976-77	10.84
1975-76	60.25
1974-75	0.58

Major Organizational Changes

The present managing director Mr. Vikram Lal (the son of the founder Mr. M.M. Lal) after completing his engineering education in Germany, joined Goodcarth Engines Private Ltd. and worked there for two years. This company was promoted by the Goodearth Company the ownership firm which floated Eicher Tractors India Ltd. Goodearth Engines was a very small unit - only 15 persons were on its payroll. Small diesel engines were assembled in collaboration with another German firm. The manager of this company did not have a technical background. Mr. Vikram Lal therefore took up all the technical functions. In 1968, he went over to Eicher Tractors India Ltd. which was in a very precarious state. He did not have any official designation and it was left to him to define his own role. For the first few years he worked in the various technical functions like materials procurement, vendor development, design of jigs and fixtures and special purpose machinery, selection of plant and machinery, production planning and control and later was designated as the Technical Adviser in charge of all technical functions.

The changes that took place in the organization arc best explained in the words of the managing director:

> *In 197.5 we got some management consultants to take a look at our operations. It still was a small company; very few people had any idea of what was what. We did not have a single, man whom we*

could describe as a good manager at that time. The company was running because of dedication and hardwork. By the end of 1974 we had reached a production volume of 100 tractors per month. We did not seem to be able to increase the volume beyond this figure. My feeling was that there was something wrong. There was no shortage of cash - we could invest in machinery if it was required -- we could have higher inventories if required. When the consultants came, they said that there was no problem with the hardware - but the source of the problem was the people'. So in April 1975 we reorganised ourselves. Three General Managers were appointed in Finance, Works and Materials with three officers at the middle management level and some at the junior levels. It was a classic case. By September 1975 the production level increased from 150 tractors per month to 180 per month in December and then it went up to 250 tractors per month without any input in terms of machinery and equipment.

The Directors reported in the Annual Report for 1975-76:

It is with the induction of suitable persons at all levels that results of 1975-76 have been possible. Employees are being imparted training in appropriate areas both inside and outside the company....

To quote the managing director again:

Rapid increase in production has its obverse side. That is we had not paid attention to the quality aspects - mainly suppliers. They could not gear up to the quality standards required by us. This situation developed gradually and was therefore not readily noticed.

By September 1976 we found that it was not possible to go further in this condition. I suspended production for a week, initially. But in fact the production had to be suspended for over a month. During this time we addressed ourselves to sorting out all quality problems vendors, within the plant, deciding on critical tolerances, developing proper control systems and so on. Immediately afterwards it was difficult to reach the previous production level. We lost production for two or three months. Since then there has been a steady increase in production....

Changes were made in the marketing organization also. Figures 1 and 2 show the differences in the organizational structure before and after the change in 1976. In the earlier set up "sales" and ' 'service" operated independently and were co-ordinated only at the level of the Director-Marketing. However, as the market became more and more competitive and more and more reports of field problems came pouring in, the management realized that customer oriented marketing department was essential for the organization's success.

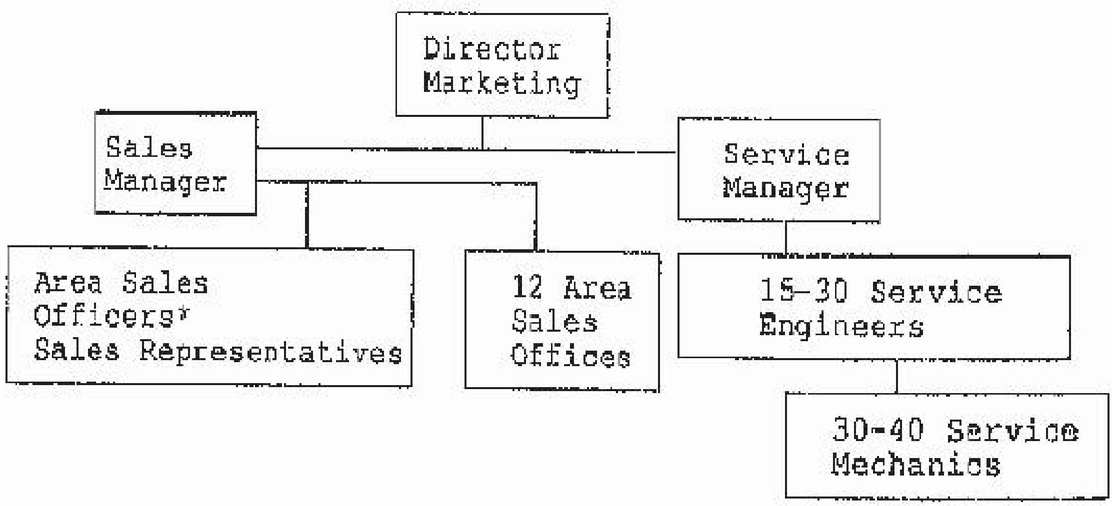


Figure 2: Marketing Organization before Change

In 1976 the marketing set up underwent a radical change. In the structure the sales and service representative is given the responsibility for the sales as well as service in a particular territory. In addition to reporting to his immediate superior, the Area Officer reports functionally to the Service Manager. The dotted lines show the information flow and communication channels between sales and service. In this set up the attempt is to link sales and service at all levels.

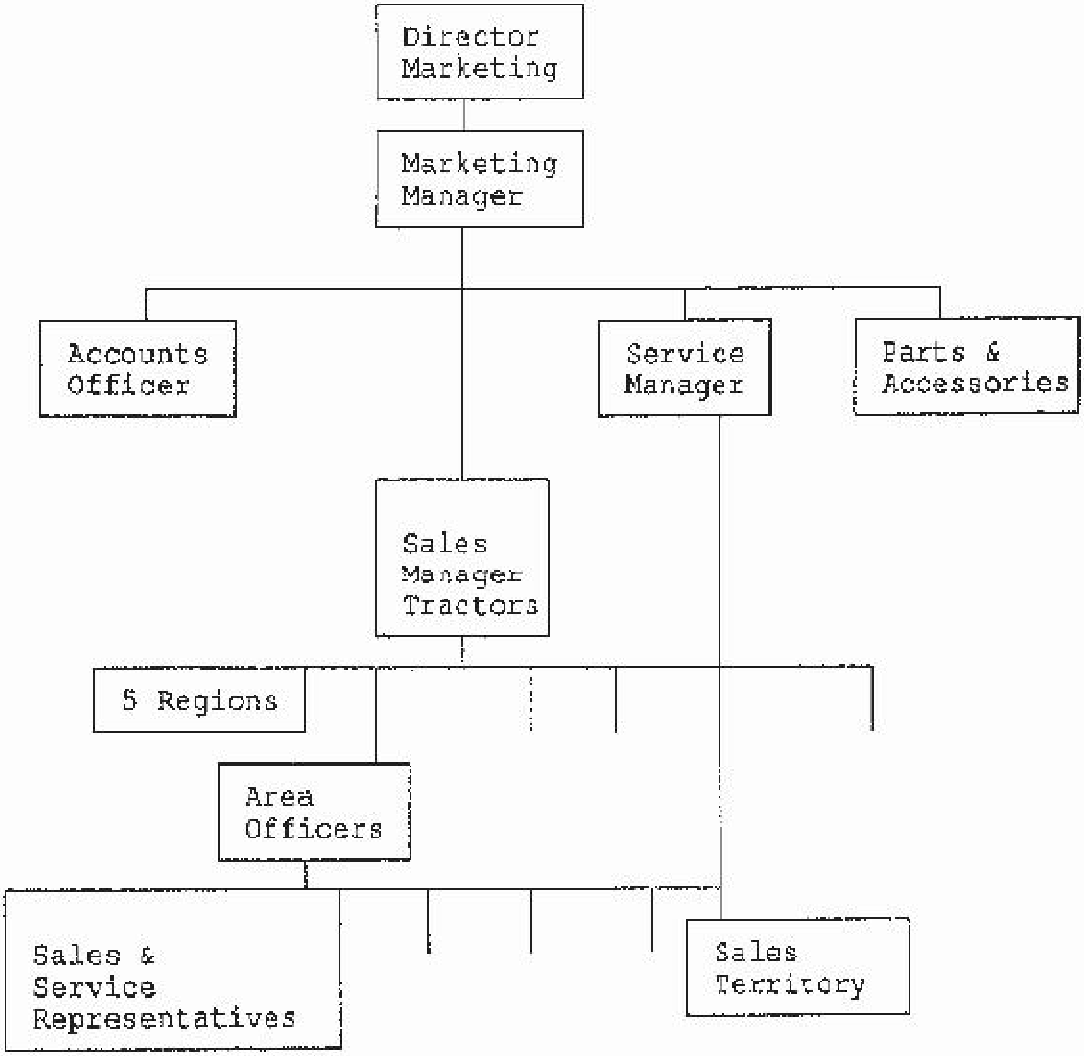


Figure 3: Marketing Organization after Change

Systematic analysis of warranty claims has been introduced and co-ordination mechanisms to look into these areas have been developed. Weekly "Warranty Meeting" are held between representatives of production, materials, quality control and service departments to deal with routine warranty and quality issues.

For dealing with critical issues which might involve major investment to improve quality or major modification in design of product, there is a co-ordination mechanism at the levels of senior managers and Director - Faridabad, General Manager - Research and Development, and Director -- Materials.

In view of the expanding operations the company decided to set up an Engine Plant at Alwar in Rajasthan. The registration is for manufacturing 7500 engines per year. The company decided to phase out the installation of capacity with 3000 in the first phase. In the words of the Managing Director:

> *Initially the Alwar Engine Plant was supposed to be a captive unit of the Faridabad tractor plant. It was that the main technical services would be centralised at Faridabad. plant of the senior officers from the Faridabad plant was sent to Alwar as the Project Manager in 1976. But soon it was found that the Faridabad Works Manager could not co-ordinate activities in Alwar properly. Communication channels did not seem to be effective. So I learnt that authority had to be given to the people at Alwar.*
>
> *At this stage it was decided to divisionalize the company. We felt that with 2 plants - the same olt functional structure would not be suitable.*

Questions

i). What is the Technology Policy of the Company? What did the company do to put the technology policy into practice?

ii). What were the reasons for, relatively quite low production level till 1969-70? Are you satisfied with whatever the -company did to overcome the problems that constrained it to keep the production volume at low levels?

iii). What features, do you notice in the finance and capital structure. of the company? Where they helpful to the company?

iv). Critically evaluate the present manufacture policy of the company and its expansion plans.

v). How is the R&D activity of the company organised? Evaluate its past and present role.

vi). Evaluate the changes recently effected in the organisation structure of the company.

EXHIBIT 1

Eicher Tractors India Limited

Summarized Income Statements for Ten Years

Unit Rs. in thousands

Sl. No.	Particulars	1967-68	1968-69	1969-70	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77
1	Sales	4345	6586	8712	15496	19044	22017	29501	37617	81572	86182
2	Miscellaneous Income	13	27	90	65	79	292	205	276	170	64
3	Total Revenue (1+2)	4358	6613	8802	15561	19123	22309	29706	37893	81742	86266
4	Manufacturing and other expenses	4171	6530	8260	14160	17548	20154	25030	32575	72505	70454
5	Finance Charges	592	572	536	703	925	1133	879	1108	1166	1286
6	Depreciation	337	381	573	487	427	555	381	540	800	1122
7	Total expenses (4 to 6)	5100	7483	9369	15350	18900	21842	26290	34223	74471	81842
8	Net Profit (loss) before tax (3–7)	(742)	(870)	(567)	215	223	467	3416	3670	7271	4378

Source: Reconstructed from the Annual Reports. There might be some errors in reconstructing the statements as the format for classifying grouping and reporting varied from year to year.

EXHIBIT 1

Eicher Tractors India Limited

Summarized Balance Sheet for a Decade

Unit in Rs. lakhs

Particulars	1967	1968	1969	1970	1971	1972	1973	1974	1975	1976	1977
ASSETS											
Fixed Assets	7.75	16.21	20.82	26.58	23.5	23.01	21.88	21.20	26.90	105.50	154.96
Investments	0.01	0.02	0.03	0.01	0.01	0.01	0.02	0.03	0.04	0.04	0.04
Current Assets, Loans and Advances	43.35	65.90	38.59	53.21	86.74	122.53	107.94	155.01	189.51	228.15	297.23
Accumulated Losses*	14.92	21.06	31.68	35.24	32.61	28.37	21.84	-	-	-	-
Total	66.03	106.10	91.12	115.04	143.28	173.92	151.68	176.24	216.45	333.79	452.23
LIABILITIES											
Share Capital	6.82	14.72	14.85	19.16	19.13	19.16	19.17	19.17	19.17	19.17	19.17
Reserves & Surplus	2.08	2.08	1.06	2.03	1.86	1.23	1.44	10.75	49.74	74.16	94.48
Loans	30.74	49.79	31.40	36.36	43.95	79.25	61.39	58.60	55.95	97.25	82.88
Current Liabilities and Provisions	26.39	39.50	43.81	57.62	78.30	74.27	69.68	87.72	91.59	143.21	255.70
Total	66.03	106.19	91.12	115.84	143.24	173.92	151.68	176.24	216.45	333.79	452.23

* Not an Asset; could have been shown as a reduction to equity - a negative reserves & surplus.

CASE 3

ESAB INDIA LIMITED

ESAB India Limited, Bombay, is a leading manufacturer of welding consumables and equipment. ESAB India Limited is the Indian associate of ESAB AB, the Swedish multinational and the worlds' largest company in welding and cutting, with production centres or representation in most of the countries.

ESAB India, a Public Limited Company with paid up capital of Rs. 50 million, employs 206 people, including 35 S&T personnel, at its Kalwa unit (Bombay) which is the major manufacturing facility. It had a turnover of above Rs. 30 crores during 1991-92. It is licenced to make 1250 nos. of welding a cutting equipment and 24020 km of welding electrodes.

The in-house R&D unit of the company employs about 10 persons including S&T personnel (scientists and engineers) and is headed by a well qualified (Ph.D.) Chief at the level of General Manager directly reporting to the Managing Director. The R&D unit is a separate entity situated within the company premises occupying a floor area of about 300 sq. mts. but closely interacts with other functional groups. It has well equipped laboratories and pilot plant facilities for development purposes. The annual R&D expenditure was about Rs. 24 lakhs during 1991-92, i.e. about 0.8% of the annual turnover. A good technical library having books, journals and periodicals in the field of manufacturing is maintained. The company also encourages close interactions with the relevant R&D organisations and academic institutions. R&D personnel participate in technical seminars and meetings in India and abroad. A computerised information facility has also been built up.

The R&D unit of the ESAB India closely interacts from time to time with the principals in Sweden and at other places on developmental needs and receives relevant technical information which is very useful for R&D in India. In fact, there are some products/areas which have specifically been developed to meet the needs of India and could be relevant to other developing countries as well, but are not covered in the product range of the principals abroad. Most of the developments relate to highly specific applications such as for oil, power, underwater uses and are import substitutes. There are immense export possibilities through constant development efforts to meet the specific requirements of other countries.

In the early eighties ESAB realised that to survive in the competitive world of welding it had to become the biggest company and a leader in technology. As a route to achieve this objective ESAB acquired a number of companies active in the field of welding and cutting. It acquired the European welding activities of Philips electrical and electronics group, based in the Netherlands in 1985. Subsequently, the welding business unit of Philips India Limited also became part of ESAB Group in July 1988. This unit was not doing well commercially. The turnover of ESAB (India) almost tripled in three years due to active marketing efforts. In May 1991 ESAB India Limited acquired the welding business of Indian Oxygen Limited (IOL), Calcutta. The turnover than approached Rs. 100 crore. The new Indian organisation now has four major manufacturing centres and has sales outlets in all parts of the sub-continent.

Technology Strategy and Policy

ESAB's objective was to become world leader in welding technology. This was to be achieved by carrying out inhouse research and by absorbing the technology of newly acquired companies. ESAB now has well established R&D facilities in a number of countries, including India. The R&D unit of ESAB (India) is a DSIR recognised unit and works presently mainly for the Indian market. In setting the objective of ESAB India, the top management of the parent company takes into account the inhouse capability and potential for further advancement through imported technology. All possible support to R&D is extended by the management to retain the leadership in its field.

The company's commitment to welding technology and product development is evident from the goal of

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Case material has been prepared to serve as a basis for class discussion. Cases are not designed to present illustrations of either correct or incorrect handling of managerial administrative problems.

the organisation which is to provide technical solutions to the customers. Here the organisation insists on the important distinction that it provides solutions and does not sell products.

In a world where technology dominates there are new opportunities for continuous development. The development of low moisture absorption welding electrodes is a good example; The offshore structures of the North Sea required welding consumables (electrodes) which would produce welded fabrication free from structural failure in a very harsh working environment. The cost of such failures could be tremendous compared to the cost of welding consumables. Typically, welding consumables constitute less than 1.5% of the total cost of the structure. The cost of failure of the structures is frequently many times the cost of the structure itself.

The early objective was to have extra low hydrogen in the weld metal. For this purpose special low hydrogen electrodes were made and then rebaked just before use. This costly process could be eliminated by packing the electrodes in vaccum sealed packages (Vac Pac) at a relatively high cost. Efforts at developing the low cost devices for packing continued. The low moisture absorption electrodes have now been produced which reduce the cost of the solution of the welding problem. At the same time the product was further developed to give improved welding characteristics in order to improve manufacturability and to reduce cost.

Expenses incurred on product and process development have to be recovered from sales so that R&D process for continuous improvement can go on. The key words which characterise ESAB's commitment to the continuous development of processes and systems are:

- the productivity of the welder and fabricator
- the quality of the weld deposit
- the working environment

Productivity

During the last decade and a half a shift from the manual welding process to semi and fully automatic welding processes has taken place in most of the developed countries, mainly to achieve higher productivity and lower manufacturing cost. Today in these markets more than half of the total production of weld metal derived from continuous solid and flux cored wires processes. It, therefore, became necessary to develop consumables to meet this challenge. Many new automatic consumables have been added.

There was a parallel development of new welding machines to match the automatic welding processes (including welding robots). The packing standards were also changed to sit automatic welding consumables for uninterrupted. supply of high-quality wire to the robotic welding processes (e.g. ESAB's Marathon Pac).

Quality

Products and services which do not meet the quality requirements of the customers do not stand the test of time. Today quality does not remain within the boundaries of the product alone. Total quality is the need of the hour. Introduction of a Total Quality Programme in the ESAB Group is a step in this direction. While finalizing the requirement for a new product the quality of the weld is inbuilt in the specification, Welding is not an end in itself. It is a process to produce a structure. The most successful welds produce the best component or fabrication at the lowest total cost.

Environment

The cost and quality of the weld very much depend on the welder who in turn is profoundly influenced by the working environment. The welder will produce better welds in a "friendly" environment or with electrodes with improved welding characteristics, a single point control (synergic control) of the welding machines and reduced fume. Controlling the toxicity limit of the welding fume shows concern towards the health of the welder whilst at the same time improving his effectiveness. ESAB's R&D is in the forefront of action to make the environment more friendly to the welder,

As can be seen, developments in welding concern the whole process and are realized by improving existing products and introducing new technologies. Attention will, in future, focus increasingly on issues relating to the internal and external environment and ergonomy. Combining ESAB's product and process research and development with the customers' production experience often lead to collaborative ventures to improve economy, quality, productivity and safety standards in the latters' works.

ESAB India Scene

The R&D department of ESAB INDIA is the focal point for all technical activities of ESAB in India. It also acts as the interface between the principals in Sweden and the Indian organisation. It undertakes research and development activities related to new products and technologies for meeting the needs of the growing Indian market. Emphasis is on continuous local technological development and absorption and upgradation of imported technologies for all the welding activities.

The department is manned by a group of highly qualified and experienced persons who have experience in other line functions so that their perceptions of the problem are realistic rather than theoretical. Members have had previous experience in quality control, production or marketing before they joined the R&D Group. They are capable of understanding the real problems or the requirement of new products as envisaged by the customer. All members of the department help each other to keep expectations within feasible limits.

Technology and product development is market led in India. For instance, in a specific nuclear project the requirements were very stringent and critical. The required product was developed in two phases. In the beginning the technical requirements were first met and subsequently the cost was reduced. Initially the market demand was not large but with time it expanded and now we have a proprietory product with large demand.

Many such market led developments have been successfully carried out in India. This has helped ESAB earn the name of a technology based company. The R&D department accordingly has established its importance in the organization and has representation in all decisions of the Group Management pertaining to technology and product management.

Methodology

If the product development is market led the marketing department has to present its requirements in regard to future market demand, possible new businesses or new applications. Once the need has been agreed the R&D department attempts to ascertain whether the product is available within the ESAB Group. If it is, the principals abroad are contacted for details of formulation and production data. In the event that a group product cannot be identified, then the R&D department of the principals combines with the Indian counterpart for a programme for development. Affer establishing the basic formulation and production data, work on adaptation to Indian conditions starts. (This adaptation is necessary because of variations in the raw materials and production plant.)

The formulations are broken into their basic chemical constituents and on them the chemical composition of the indigenous raw materials is superimposed. Imbalances are suitably adjusted to provide the correct weld metal analysis and welding characteristics of the electrode. Theoretical knowledge and practical experience are essential for doing this. A tentative formula is obtained which is refined through experiment to give the final desired product. The new formulation is first tried on pilot plant and subsequently transferred to production. For successful development and commercialisation of a product, marketing and sales, materials management and production departments are all involved. The R&D personnel remain involved till the product is established commercially. R&D must also be involved in manufacturing technology to meet the company's own demand for improved productivity, quality or to increase manufacturing flexibility.

Difficulties Encountered

What has been discussed above works if the situation is ideal. Reality is often different. Some of the major difficulties encountered in actual practice relate to:

- changes in specifications during the development period
- failure to achieve the required result by the R&D department
- unduly long. response time of development
- prohibitive cost of product.

In the course of the development the customers' needs may change. If such a change is not very major, it may only cause a small delay but in case of major changes it may mean development in an entirely new direction. Alternatively, the specifications may sometimes be too stringent that it may not be possible to manufacture a new product within the constraints and the projected cost. It is also possible that the largest laid down in the guidelines received from the principles cannot be met because of non-availability of specific raw materials at reasonable prices. These are all major handicaps in developing the desired product.

Undue delay in developing a product any result in losing market opportunity for which it was intended. Often development may use costly materials and the finished available product may become more expensive than an alternative product in the market resulting in failure to develop a commercially viable product. All problems and difficulties described above combine into one single problem-loading the interest of the customer. These difficulties cart arise in market led development. However, if development is production led, many new and good developments never reach the market because they do not satisfy a recognised customer need. In relation to development activity, the following observations of general nature can be made:

1. The top management must commit itself (through the company objectives) to render active support to development of product and technology. Often in hard times expenses incurred to development come under the microscope. The commitment of the top management will ensure that in the long-term, investment in R&D activities will pay off handsomely.
2. Development is not a single department's job. Active involvement from marketing and sales, production and materials management is essential to make .the new product reach the customer ... at right time and at the right cost.
3. Cost of the product plays an important role in the development efforts. This point must be kept in mind from the very beginning. A developer must be fully conversant with the cost structure of the product.
4. All industrial R&D activities must have commercialization of the development as its goal. Any development will be termed a failure if it does not improve the bottom line of the organization.
5. Many difficulties may be faced during the R&D process, so no R&D is assured of a quick and easy success.
6. Guidelines and directions from the principals from abroad are only part of the story. Local R&D is important to satisfy local needs and constraints. "Appropriate technology" is the need for all R&D effort while adapting' products and technologies from abroad.
7. ESAB India's role in future will be to develop the existing techniques and to participate in the research and development of new techniques with a view to maintain its leading position in the field of welding and cutting in the 21st century.

Opportunities for ESAB India

In the International scenario the technological developments are taking place at a very rapid pace. India with its wealth of technical expertise should adopt overseas technological advances for speedy commercial implementation and benefit from them. Such adaptation will hasten the process of industrialisation, Indian R&D efforts should be directed initially towards meeting the local needs and overcoming local constraints by suitable adaptation but finally we must aim to be a world competitive supplier of welding and cutting solutions.

Questions

1. What strategic route ESAB AB followed to become technology leader in the world? What could be the reasons behind such a route?
2. What efforts were made by ESAB AB and ESAB India in the field of product development?
3. How is the R&D function at ESAB India organised? Critically examine,
4. What difficulties ESAB has experienced in relation to product development efforts? What would you suggest to overcome these difficulties? What opportunities are open to ESAB India? How best can it avail of those opportunities?

CASE 4

HINDUSTAN TRACTORS LIMITED (AR)

Pashabhai Patel, Chairman of Hindustan Tractors Limited, Baroda, was wondering what options he had as he reviewed the performance of the company during the year ended March 31, 1972. The production (375 tractors) amounted to less than 20 per cent of the peak achieved in 1968, and formed only 13 per cent of the installed capacity. Operations in 1971-72 had resulted in a loss of Rs. 81 lakhs on a turnover of Rs. 1.88 crores. It was the fourth consecutive year of deficit. Cumulative losses at the end of March 1972, at Rs. 1.18 crores, exceeded paid-up capital of Rs. 1,000 crore. No preference or equity dividends had been paid for three years. Secured and unsecured loans, at Rs. 4.52 crores, were fully stretched, and the company had defaulted on payments to fixed depositors (Exhibit 1).

He was aware that it would be quite some time before the upward revision statutory price fixed by the Government of India helped the company financially. While the picture was gloomy, closing down the plant was not an easy option; Pashabhai was aware of the importance the government gave to increasing the production of tractors, an essential commodity, and of the continued demand for tractors in the country. The Government had, in fact, appointed a committee under Section 15[1] of the Industries (Development and Regulation) Act, 1951, to investigate into the fall in production of Hindustan Tractors.

Historical background

The company was founded by Pashabhai Patel, businessman-cum-politician, a relative of Sardar Vallabhabhai Patel and a close associate of Mahatma Gandhi. Pashabhai left Baroda College in 1921 in response to Mahatma Gandhi's call for non-cooperation. He was intrigued by an imported tractor he saw at the Baroda model form of Maharaja Sayajirao. He started custom hiring and custom ploughing in Surat/Bulsar area with a fleet of imported tractors: Later he started tractor repairs and their import, sales, and service. A forceful person, and considered an outstanding salesman, Pashabhai pioneered the use of tractors in remote villages.

Pashabhai Patel & Co. Private Limited (a predecessor of Hindustan Tractors Ltd.) was formed in September 1946 for the import, sale, and service of tractors, ploughs, bulldozers, and other farming and earth moving equipment. As plans for entry into manufacture took shape, a new company, Tractors and Bulldozers Private Ltd., was formed in 1959 and became the successor for company to Pashabhai Patel & Co. Private Ltd. It was in turn converted into a public limited company in 1964 with Pashabhai & Co. as the managing agents. Pashabhai Patel and Co. were associated with other companies making earth moving and construction equipment and tractor parts. One such company, the Hindustan Earth Movers Private Ltd., was located on adjacent land which it had leased from Hindustan Tractors Ltd., at Viswamitri in Baroda, and supplied several components.

Hindustan Tractors had financed Construction Equipment Co. Pvt. Ltd., with Rs. 12.4 lakhs. It became 'an associate of the managing agents in May 1965. Although the money was repaid by March 1966, the company directors had contravened Sections 295, 369 and 370 of the Companies Act, 1956.

In February 1965, equity shares of Rs. 50 lakhs were issued to the public. Pashabhai Patel, his relatives and friends held about 50 per cent of the equity in 1972. The Life Insurance Corporation of India, the Unit Trust of India, nationalized banks and insurance companies held 35 per cent of the equity. The Life Insurance Corporation held almost 100 per cent of the preference shares issued in 1968.

Pashabhai believed in direct action whether in politics or business. He was arrested and put in jail for two years when he withheld the payment of tax of Rs. 1.9 lakhs in protest against the imprisonment in 1943 of Mahatma

[1]The central government could have an investigation made of any scheduled industry or undertaking under Section 15 if it was of the opinion that a) production had unjustifiably fallen or was likely to fall, or b) there was or likely to be an avoidable deterioration in quality, or c) there was or likely to be an unjustifiable rise in price, or d) an undertaking was being managed in a manner detrimental to public or industry, interests. Based on, or even during such an investigation, the government could issue under Section 16, directives on production, price, distribution, or on any other relevant aspect.

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Gandhi, Nehru, and Sardar Patel. The government sealed the premises and the business was halted. Pashabhai paid up the amount after the release of the leaders and on the advice of Mahatma Gandhi. In 1963, he was' involved in another tax inquiry and admitted tax evasion. A Parsi lady relieved from the company's service because of some quarrel with him had complained about this tax evasion to Feroze Gandhi, a member of Parliament. An enquiry was made when Feroze Gandhi sent the complaint to Morarji Desai, the then Finance Minister[2]. The inquiry ended with a compromise between Pashabhai and tile Income Tax Department.

In 1967 Pashabhai was elected. to the Lok Sabha from Baroda on a Swatantra Party ticket.. He continued as Chairman of the company. The company changed its name to Hindustan Tractors & Bulldozers Ltd., in 1965 and -to Hindustan Tractors Ltd., in 1967. When the managing agency system was abolished in 1970, brothers Chandrakant and Indrakant, who were members of the board of director§ earlier, became its managing directors.

Organization

The company was run by Pashabhai Patel and his relatives (Exhibit 2). There were very few non-family members in executive positions.

Nagindas, a brother, was' the first to join Pashabhai. Chandrakant and Indrakant joined in 1940 after a spell of training in USA, in the manufacture, sale, and service of tractors. Rameshchandra Patel, sales manager, and Niranjan Patel, foundry manager,_ both nephews of Pashabhai, joined the company in 1954. They had earlier undergone training with Vickers-Armstrong in UK and Allis-Chalmers in USA. Rashmikant Patel, the joint works manager, another nephew joined the business after obtaining a B.Sc. (Tech.) degree.

Family relationships were more important in practice than formal titles or organizational boundaries. The position of Pashabhai in both the Patel family and in the business was dominant one. Sales, purchase, finance, government relations, and production were handled by family members. S.P. Suji, works manager, was one of the few nonfamily executives. Pashabhai, shrewd judge of opportunities and people, had contacted Suji in 1967 within three days of his leaving Premier Automobiles Ltd., Bombay, where he had worked for 22 years.

Pashabhai was far-sighted in his understanding of the role of tractors. His early attempts to make a plough failed but he had a keen business sense and was ahead of many in starting its manufacture in India. He travelled many countries, saw many tractors, met with many farmers around the world before picking on the Zetor 50 h.p. tractor for manufacture.

Entry into Manufacture

In. 1960, the Tractors and Bulldozers Private Ltd. entered into a technical collaboration with Motokov, a Czechoslovakian state-owned foreign trading corporation, and with Zavody Jana Svermy, a Czechoslovakian state enterprise. The agreement provided the company exclusive rights to manufacture and assemble 50 h.p, Zetor Super tractors, a model that had proved popular with Indian farmers when imported in 1961. The Czech company was to provide technical know-how, drawings of tools and fixtures, and necessary components on nine months credit, and to train personnel sent to Czechoslovakia at the Indian company's expense. In return the Indian company was to pay the Czech party a royalty of five per cent, subject to Indian taxes, of the net ex-works (as of Brno, Czech.) selling price of components manufactured in India. The price of Zetor Super 50 was fixed at £700 in 1964 The' Indian company had rights to export to Nepal, Burma (where there was a, 50 h.p. Zetor unit), Singapore, Thailand, and other South East Asian countries.

The agreement required Hindustan to buy at least 50 per cent of the value of 1000 tractors in the first year, 30 per cent in the second year, and 20 per cent for the next eight years.

Production of 50 h.p. tractors started in February 1963. Manufacturing facilities had been established for 50 h.p. while the company was mainly. an assembler of 35 h.p. tractors. The collaborators helped in the assembly operations also. Both the licensed on installed capacities had been increased over the years. At the peak production of 1967-68-1, 194 50 h.p. tractors and 838 35 h.p. tractors-the utilization of installed capacity was over 70 per cent (Exhibit 3).

In 1968, Hindustan Earth Mover Pvt. Ltd., a sister concern, obtained an import licence for 100 crawler tractors of 100 h.p. and 50 of 50 h.p. They were imported at a cost of Rs. 1.27 crones from 14 Oktobar Rudnap, a

[2]Morarji Desai, The Story of My Life, Vol. 2 (Delhi: Macmillan Company of India Ltd., 1974), pp. 205-206.

Yugoslavian/firm with whose collaboration Hindustan Earth Movers had plans to manufacture track type crawler tractors.

Other Manufacturers

In 1972, Hindustan was the smallest of six units in regular production. The International Tractor Company of India was the largest; it made tractors of 35 and 44 h.p. It was set up jointly by the Mahindras, who were in the automotive business manufacturing jeeps, and the Voltas, who used to import International tractors earlier, in technical and financial collaboration with the International Tractor Company of UK. Tractors and Farm Equipments Ltd., Madras (part of the Simpson group which made Perkins diesel engines, piston rings, and automobile ancillaries), manufactured 35 h.p. tractors in financial and technical collaboration with Massey Ferguson of Canada. Escorts which was already in the automobile industry started with the manufacture of agricultural implements and then set up a unit to manufacture 37 h.p. tractors using diesel engines of Kirloskar Oil Engines and in technical collaboration with Moto import of War Poland. Escorts had also started manufacturing 40 h.p. tractors in collaboration with the Ford Motor Company of USA and were planning to make their own diesel engines. Eicher of Faridabad and Hindustan Machine Tools manufactured smaller horsepower tractors of 27 h.p. and 25 h.p. respectively. Eicher had German collaboration, while HMT had collaboration with Motokov 'of Czechoslovakia. Exhibit 4 gives some details about various manufacturers.

Production

The Hindustan tractors had over 1,200 parts, some highly specialized. The 50 h.p. tractor weighed nearly 2.7 tons. The majority of the. components were bought from ancillary units. Hindustan made a larger proportion of components than other tractor manufacturers. It was the only unit, to make its own engines and several castings. The final operation was an assembly of different types of items-ferrous and non-ferrous machined castings, carbon and alloy-steel machined forgings, sheet metal fabricated parts, and rubber, instrumentation, and electrical, items. acct materials cost ranged between 80 and 90 per cent of the total ex-works• cost 'depending on volume and male.

Mr. Suji, works manager, a soft-spoken production engineer, thought highly of Hindustan tractors:

> Our 50 h.p. tractor is sturdy and a little overweight. The modern tendency is to put weight and direct material costs. But our tractors have a 50 per cent longer life. I have seen 12-year old tractors in use and have tested. our 50 h.p. engines up to 60 h.p. without any difficulty. In this business, procurement of raw materials and imported and local components and their availability on time are critical.
>
> After I joined Hindustan in 1967, I introduced a work order system, worker efficiency cards, and an industrial engineering department. Data on materials consumed and labour time used were supplied to the Planning Section, Systematic costing and planning have, however, lagged partly due to high turnover and frequent changes in planning engineers.
>
> In 1962, the company set up a captive foundry. We have a modem machine shop, with a capacity for sophisticated operations. 'We subcontract to units in Bombay, Calcutta, and Madras. We are the only automobile unit in the state, and there are no ancillary units in Gujarat.

Mr. Suji thought that the company's plant and machinery were good but poorly maintained. In 1971-72 only Rs. 19,000 had been spent on machinery repairs as. against 'Rs. 2.4 lakhs in 1967-68.

Demand for. Tractors

According to a study conducted by the National Council of Applied Economic Research, the. potential demand for tractors was ,high in India. Demand Estimates varied widely. The Indian Agricultural Research Institute, Delhi, estimated that 1,750,000 tractors would be required during the Fourth Plan period (1966-71), of which 250,000 tractors would be between 28 and 50 h.p., the range manufactured by large tractor producers. The estimates of the Planning Commission were much lower-150,000, of which about 110,000 were to be in the 20 to 50 h.p. range. Individual manufacturers had their own estimates generally closer to the Planning Commission's figure.

Indigenous production had increased from nil in, 1960-61, to nearly 20,000 in 1970-71. To meet the gap, between demand and indigenous production, the government allowed tractor imports mostly from the Soviet Union and other East European countries. Exhibit 5 provides some data on the availability and growing use of tractors in India.

Demand Trends by Horsepower Range

Nearly 80 per cent of the indigenous production was in the medium horsepower range, around 35 h.p. Manufacturers had yet to develop special purpose tractors and a full range. On the basis of a national sample survey of farms, the NCAER Plot that the preponderance of 35 h.p. tractors was more an indication of its availability than of farmer preference.

The Indian Agricultural Research Institute and the Planning Commission estimated a large requirement of lower horsepower tractors, while industry representatives thought that the trend would be towards higher horsepower tractors. Manufacturers told the Tariff Commission in 1967 that they could make 18 to 20 h.p. tractors, but did not think they could offer them at prices much below those for the 35 h.p, tractor; they could reduce the prices by about Rs. 1,500.

The smaller horsepower tractors of up to 25 h.p. were more in use in the deltaic states of Bihar, Andhra Pradesh, and Tamil Nadu, while the higher horsepower tractors, were more common in the Terrai areas of Maharashtra, Haryana, and Uttar Pradesh. The distribution of tractors in use in 1972 by horsepower and the expressed preferences of farmers are given in Table 1.

Table 1 Percentage Distribution of the Use of Tractors and the Preference of Farmers by Horsepower

Horsepower	Use	Preference
Up to 25	29	22
26-35	43	62
36-59	16	6
Above 50	1	10

Source: Demand for Tractors (Delhi: NCAER, 1974).

Tractor Customers

Tractor buyers were mostly owner-farmers of substantial means. Dealers had long waiting lists of eager customers who were willing to pay a premium for immediate delivery. The used tractor market was also good. A survey in 1972-73 in two talukas of Gujarat showed that many farmers had paid prices higher than average market prices.* The premium range is given in Table 2.

Table 2 Tractor Prices Paid by Farmers

	Average	Range of premium paid	
Year.	Market Price	(new and used)	%
	(Rs.)	Rs.	
1960	16,570	6,430	39
1966	19,745	9,255	47
1967	19,746	4 to 3,354	0 to 17
1968	20,870	130 to 1,583	1to8
1969	20,870	630 to 4,330	3 to 21
1970	20,870	7,630 to 9,520	37 to 46
1971	22,580	5,127 to 7,352	23 to 33

***Source:** M.S. Patel, "Effect of Tractorisation on Tractor Prices", The Economic Times, (January 1, 1976).

Manufacturers had provided no credit facilities. The farmers in the two talukas of Gujarat relied to a large extent on their own resources. Land mortgage banks, state departments of agriculture, banks and state agro-industries corporations provided credit facilities for the purchase of tractors.

Marketing Practices

Manufacturers carried small quantities of finished tractor stocks in the late '60s and the early '70s. Under the government's distribution control order, a dealer was required to give a 90-day notice to the first customer on their waiting list who had booked an order. On receipt of the consignment he was require to give in writing a notice of 30 days for payment. If the customer failed to. make such payment, the dealer could turn to the next customer.

Marketing practices varied form manufacturer to manufacturer, partly depending on the collaborators. Tractors and Farm Equipment Ltd. and International, through their sole selling agents Voltas, provided free installation services and some training to the farmers. Through an Installation Certificate TAFE collected data on where each tractor it sold was located and who the buyer was. Besides it maintained a 200-acre farm and a Product Training Centre where it trained its dealers.

None of the manufacturers spent much money on advertising. Voltas published a journal on mechanized farming and other news of interest to farmers.

In 1966-67, of the four manufacturers, Hindustan with Czechoslovakian collaboration spent the least on selling-Rs. 98 per 35 h.p. tractor and Rs. 123 per 50 h.p. tractor. Selling expenses were the highest for Voltas. Escorts' selling expenses were Rs. 562 per tractor and TAFE's Rs. 309. The government fixed uniform selling expenses for all manufacturers including a dealer's commission of. Rs. 2,050 per 50 h.p. and Rs. 1,850 per 35 h.p. tractors.

Punjab, Haryana, Uttar Pradesh, and Rajasthan accounted for nearly 60 per cent of the tractor population in 1966. Selling and Distribution .

Hindustan sold through a small network of about 30 dealers all over India. It gave a warranty of six months to farmers and of one year to government departments. It provided after sales service directly to government departments and through dealers to the general public. Dealers paid cash on delivery; they were paid a commission of 10 per cent on the ex-factory selling prices. The freight and forwarding charges were charged separately.

Government Policies

Entry into the industry and expansion of capacity were controlled by the government, as in other industries. The heavy capital requirements posed a barrier,' although banks' and financial institutions provided considerable finance. The industry, relied heavily on external sources of funds.

Licensing during the late 1950s and the early 1960s was based on the low figures of estimates during the First and the Second Five Year Plan. This, along with the government policy of encouraging competition, has resulted in several small-volume manufacturers with different collaborators. Because of the specialized nature of design of each tractor and the lack of standardization of components, ancillary units experienced no economies. The view in the mid-1960s was that an economic volume of production was not less than 10,000 tractors a year. Hence when the government licensed additional capacity in 1965-66 to cover the gap between estimated long-term demand and likely production, most of it went to existing units, Escorts was the only new unit. To bridge the immediate gap between demand and supply, the government imported tractors from various countries, mostly East European countries.

In 1971, an additional capacity of 36,000 tractors was licensed-Kirloskar (10,000), Harsha (10,000), Escorts (6,000), Perfect (5,000), and United Auto (5,000). Several letters of intent were also given.

Most of the tractor manufacturers-TAFE, International, Escorts-were earlier in the automobile and ancillary industry and all entered into foreign collaborations for the manufacture of tictors. Escorts was planning to integrate backward from tractors to the manufacture of oil engines, while Kirloskar, was integrating forward from oil engines to tractors. Hindustan Machine Tools was diversifying from machine tools to tractors. Such growth and diversification required long-term planning and commitment as suppliers of plant and machinery and vendor development took a long time.

Research. and Development

Research and development expenditures were low and mostly geared to developing local supplies of complicated components and to finding acceptable substitutes for expensive materials. New indigenous model development was non-existent. Vendor development and quality and cost control were key problems for the industry. Procurement of tyres was also difficult at times. As assemblers, tractor manufacturers were affected by strikes, power cuts, and raw material shortages at supplier units.

Indigenization received a boost when the government banned the import of complete tractors in 1963. Import licenses were based on indigenization targets. The pace of indigenization was slow but steady. Over 70 per cent indigenization had been achieved by 1972. With each CKD import consignment some items were expected to be deleted by manufacturers as they made arrangements for either buying them locally or for own manufacture. A Tariff Commission study of 1967 showed that the cost of indigenizing a rupee of the c.i.f. (cost, insurance, and freight) value of deleted items ranged from 95 paise to Rs. 1.62, depending on volume and other factors. In one instance, considered small and non-representative, the cost of replacement was as high as Rs. 3.16. In 1972 it was difficult to get indigenous suppliers for many complicated forged and machined components such as crankshaft, camshaft, and differential bevel gears.

Price Control

The good demand for tractors and the tight supply position had led the government to impose price and distribution controls. In early 1967, the government of India declared tractors as an essential commodity within the scope of the Essential Commodities Act, 1955, and initiated price control.

Before the price controls were introduced in 1967, Hindustan tractor prices were less than those of the others. The Hindustan 35 h.p. tractor was priced at Rs. 13,350 as against International's price of Rs. 19,835 prior to devaluation in 1966. Hindustan had difficulty supplying the cost data requested by the Ministry o1 Finance (Cost Accounts Branch). One reason was that it did not maintain adequate cost record. The statutory prices were fixed for the first time in mid-1967. Prices fixed for Hindustan were less than the company's selling prices at that time by 6.5 per, cent for 35 h.p. and 8 per cent for 50 h.p. tractors.

The Tariff Commission conducted a regular price investigation in 1967. According to the Tariff Commission's cost estimates for 1967-68, the direct cost of materials accounted for nearly 80 per cent of the ex-factory costs (Exhibit 6).

In October 1967, on the basis of cost plus 15 per cent return on capital employed (net fixed assets and four months' cost of production as Working capital), the Tariff Commission made recommendations on prices to be effective for two years up to March 1969. The prices recommended varied from unit to unit; for 35/37 h.p. tractors prices varied by nearly 36 per cent from Rs. 15,680 for Hindustan to Rs. 21,270 for Messey Ferguson of Tractors and Farm Equipment Ltd., Madras (Exhibit 7). Although this approach to price fixing did not provide an incentive to high-cost units to reduce cost, it was considered necessary because of the widely different collaborations, import content or stages of deletions, royalties, production volume, location, costing methods, etc.

The Tariff Commission recommended escalation clauses for changes in rates charged by collaborators for Completely Knocked Down (CKD) packs or for deletions of items. No escalation was provided for an increase in rates of indigenous items, except for engines in the case of Tractor and Farm Equipment Ltd., Madras, which used Perkins engines made by a sister concern, Simpson & Co. Ltd., Madras, and Escorts which used Kirloskar engines of Kirloskar Oil Engines Ltd., Poona. Where fresh delegations were replaced by indigenous items no escalation was provided as the 57.5 per cent devaluation of June 1966" was considered an adequate cover. These escalation clauses were accepted by the Government of India.

Based oh the Tariff Commission's report, the Ministry of Industrial Development and Company Affairs, Government of India, revised the statutory selling prices of tractors in June 1968 with immediate effect (Exhibit 7). The prices fixed by the Ministry were less than those recommended by the Tariff Commission (in all cases except Escorts). The government allowed only a 12 per cent return on capital employed, .consistent with the amount allowed to other industries, while the Tariff Commission had recommended a 15 per cent return. The difference accounted for the price reduction of Rs. 247 for TAFE, Rs. 321 for International, Rs. 165 for Escorts. The government made other adjustments-in the case of TAKE and International for the devaluation of the pound sterling in November 1967 and in the case of Escorts for double counting by the Tariff Commission of some items, once in the CKD pack and once in locally bought or manufactured items. For Hindustan 50 h.p. tractors, the government reduced drastically the replacement ratio of 300 per cent allowed by the Tariff Commission for expected deletions of items from CKD packs.

Pashabhai, like the other manufacturers, thought that the statutory prices were unremunerative. He felt that Hindustan's prices were fixed particularly low and was quick to represent to the government the serious impact the "un-realistic" statutory prices would have on the profitability of the company. Upon repeated representations, in 1969, the government asked the Bureau of Industrial Costs and Prices to examine the costs and prices of Hindustan tractors, but later, in September 1970, requested a de novo examination of costs of all makes. Based on their report the government revised upwards the statutory prices in September 1971. A substantial increase in prices-over 30 per cent was granted in 1972 because of sharp rises in prices of raw materials and components.

Purchase Policies

Nearly 300 of the 1,200 parts and components of Hindustan tractors were made at Hindustan, a proportion of somewhat higher than that of competitors. Hindustan Earth Movers Private Ltd., a sister concern, supplied nearly 140 items. For the other parts, Hindustan had about 150 suppliers located at Bombay, Madras, and Calcutta. For some items there was only one supplier. For many others, splitting the small-volume specialized orders among suppliers was expensive. The tools for making the parts customarily belonged to the suppliers although they were paid for by Hindustan. The company had developed and encouraged several ancillary 'units.

The geographical distance between the factory and the suppliers posed several problems of cost, delivery, and quality coordination. The company maintained high inventories of raw materials, components, and work-in-process whose value was in excess of sales from 1969-70. Strikes and power cuts at supplier factories, market conditions and availability of items, such as tyres and batteries, affected Hindustan's operations. Quality problems on forgings were severe. In spite of high inventories, completion of tractors was often delayed for want of critical items, and this resulted in high-in-process inventory.

Hindustan was dependent on the Czechoslovakian collaborators for the supply of some 12 critical items such as the crank shaft, the cam-shaft connecting rod and crown wheel and pinion. There were no Indian suppliers'for these items.

Indigenization

Although the pace of indigenization had been slow in the industry, Hindustan had kept in, line with other manufacturers in import substitution. For the 50 h.p. tractors, Hindustan manufactured or had local suppliers in 1970-71 for items equivalent to 85 per cent of the c.i.f, value of a completely imported tractor against the target of over 90 per cent set by the Government of India (Exhibit 8). The Tariff Commission had noted that Hindustan had resorted to the import of components outside the CKD packs so that the actual number of components deleted was less than the apparent number in CKD packs, which it pointed out was "against the spirit of import substitution". In 1966-67, Hindustan had imported components worth Rs. 633 outside CKD packs for 50 h.p. tractors on a c.i.f. value of Rs. 7,323 for each pack, which the Commission used as the basis for determining its cost of production.

The managing director, Chandrakant Patel, commented on the import of components outside the CKD packs as follows:

> It was done only once and represented only a small percentage of the pack value. Components had to be imported as an indigenous supplier had failed to deliver the goods at the last minute.

Personnel and Industrial Relations

The company employed 1845 workers when in peak production in 1968. Pashabhai handled most of the personnel matters. He was a hard driving man and had not recognized any union. Wage rates at Hindustan were lower than those of other companies in the area. Most of the workers were temporary and their turnover was high. Unskilled workers from neighbouring villages would gain experience and quit without notice when they got better jobs.

Supervisory turnover was also high although the wage disparity in their case was not large. Supervisors left if they could not get along with the family members particularly Pashabhai or meet their expectations. Pashabhai rewarded those he liked and those who put up with his ways.

The unrecognized union was led by Sanat Mehta, member of the Praja Socialist Party, the Gujarat State Legislative Assembly and a prominent politician. The Engineering Wage Board recommendation, which would have increased wage scales by nearly 50 per cent for the workers had not been implemented by the company.

An illegal one-day strike in October 1970 on a dispute. regarding payment of bonus was followed by a lock-out . that lasted 35 days. Chandrakant Patel described the strike as follows:

> The strike was politically provoked by Sanat Mehta's union for reasons best known to them. The management was very firm and when the workers realized their mistake, they quickly approached Pashabhai and requested him to allow them to work. They signed an agreement with the company not only apologizing for the strike, but accepting all the conditions including no salary for the lock-out period and unconditional resignations of the[1]r ring leaders.

The company retrenched 560 workers in May 1971, mostly unskilled workers in the foundry and machine shop. They were paid 15 days retrenchment compensation, one month's salary for every year of service, and privilege leave salary.

In 1972 morale was low and there was no work for many as quite a few production departments had been partially or wholly closed down.

Financial Policies

Pashabhai was worried about the serious financial stringency of the company. Pashabhai considered the government's price control to have crippled the company. Several of the risks he had taken with the expectation. of an early increase in tractor prices had proved very costly. Even maintaining the already low production volume had become difficult. Work in several production departments had been stopped.

The company had a hypothecation limit from the State Bank of India of Rs. 95 lakhs against the security of raw materials, components, finished goods, and other inventory. The bank had also sanctioned a limit of Rs. 225 lakhs for opening letters of credit to foreign countries. The bankers had taken personal guarantees from Pashabhai and his brothers in addition to the hypothecation of all moveable assets before granting these limits.

Secured loans were more than three times the equity and the interest burden had nearly tripled from Rs. 18 lakhs in 1969-70 to Rs. 53 lakhs in 1971-72. The directors had foregone their salaries and the board members their sitting fees in view of the continuing losses of the company. Labour was paid on time though the increase recommended by the Engineering Wage Board had not been implemented, and bonus payments had been delayed.

Supplier credit had been stretched to the limit domestically, and there were occasional defaults on letters of credit opened by the bankers and in payment of royalties to collaborators. The company's accounts with the bankers had become irregular. Some of the fixed depositors were threatening to file suits for liquidation proceedings.

Most normal financial sources, including the director's own, were exhausted. Pashabhai was seeking cash credits from the State Bank of India, the company's bankers, who were now insisting on guarantees from the state government or financial institutions.

Industry Profitability

The Industry profitability was generally lower than the average for all industries. Gross profits as a percentage of capital employed was 5 per cent for the tractor industry in 1969-70 as against an average of 9.9 per cent for all industries (Exhibit 9). The industry's performance was affected severely in 1970-71 because of a sharp rise in the cost of raw materials and components while tractor prices remained fixed at an earlier level. Several units went into the red. The industry's reliance on external sources of finance was high-owned funds formed only about a third of the total capital employed.

Tractors and Farm Equipment Ltd., in spite of its larger volume, had suffered losses (Rs. 35 lakhs on a turnover of Rs. 5.4 crores) in 1970-71. International had not slipped into the red yet but its gross profits had declined from

10 per cent of capital employed to 6.7 per cent in 1970-71, and profits after tax had dropped from Rs. 63 lakhs in 1969-70 (sales Rs. 9.7 crores) to Rs. 4.2 lakhs in 1970-71 (sales Rs. 11.4 crores).

Hindustan's profitability was the poorest but Pashabhai was hopeful that Hindustan would turn the corner in view of the substantial price increase of February 1972. But the immediate problems of turning the company around were overwhelming.

Questions

1. Identify the problem or. the central theme of the case.
2. What internal and external factors have been responsible for the deterioration in performance of the firm?
3. Do you think that as a Chief Executive Officer of the company Pashabhai Patel failed in .the proper discharge of his duties or responsibilities.
4. Identify any other points relating to the case and present your analysis.

Exhibit 1
HINDUSTAN TRACTORS LIMITED (AR)

Balance Sheet

(Amount in Rs. Lakhs)

	As on March 31							
	1965	1966	1967	1968	1969	1970	1971	1972
ASSETS								
Fixed Assets								
Land & Buildings	29.6	35.7	39.3	42.1	43.5	44.0	44.1	44.1
Plant & Machinery	45.7	78.1	95.1	149.9	170.3	170.4	170.4	170.1
Others	5.1	6.4	6.6	8.8	12.4	13.2	13.5	12.1
Acc. Depreciation	23.1	32.6	42.6	54.4	37.1	47.3	57.0	66.9
Net Fixed Assets	57.3	87.6	98.4	146.4	189.1	180.3	171.0	160.4
Machinery to be installed	25.0	16.3	22.3	22.1	—	37.1	41.0	41.0
Current Assets								
Raw Materials & Comp.	56.8	107.1	191.7	223.2	234.0	254.1	224.4	190.3
Work-in-Progress	37.7	7.7	14.2	30.9	28.7	39.8	57.2	50.1
Stock in transit	18.4	30.7	1.2	28.0	39.0	110.4	6.0	6.1
Trading & Fin. Goods	5.2	10.1	14.6	9.2	7.0	43.4	90.4	51.7
Tools, Jigs & Stores	11.8	14.3	22.8	27.6	30.8	38.3	34.8	28.4
Inventories	129.9	169.9	244.5	318.9	339.5	486.0	412.8	325.6
Accounts	35.0	42.7	41.5	38.0	42.7	49.1	31.8	44.9
Cash & Bank Balance	34.6	3.7	52.7	3.2	5.4	9.0	5.5	4.6
Earnest deposits and others	3.2	17.3	18.6	10.1	15.2	17.2	22.7	16.5
Advance tax payments	17.5	25.1	54.7	62.5	66.8	66.8	69.5	73.3
Current Assets	220.2	258.7	412.0	432.7	469.6	628.1	542.3	465.9
Other Assets	2.1	2.1	0.2	1.0	0.9	0.9	1.1	0.9
TOTAL ASSETS	304.6	364.7	532.9	582.2	659.6	846.4	755.4	668.2

Exhibit 1 (Contd.)

HINDUSTAN TRACTORS LIMITED (AR)

Balance Sheet

(Amount in Rs. Lakhs)

	As on March 31							
	1965	1966	1967	1968	1969	1970	1971	1972
LIABILITIES								
Share Capital: Equity	36.7	69.8	70.0	70.0	70.0	70.0	70.0	70.0
9.5% cum. Preference	—	—	—	30.0	30.0	30.0	30.0	30.0
Reserves	25.5	38.5	38.5	53.1	60.0	27.8	(38.0)	(117.6)
Short-term Loans								
From Banks	17.1	54.4	29.1	75.4	90.7	104.4	343.4	310.0
From Directors & others	2.7	0.3	0.7	0.5	—	—	—	—
From Public (Fixed deposits)	—	—	—	19.3	43.6	61.9	60.3	49.1
From Dealers	6.5	6.7	5.2	5.0	15.8	—	—	—
From Others	18.2	2.6	13.6	5.8	20.4	84.7	75.1	92.5
Current Liabilities								
Acceptances	128.8	101.2	270.7	187.6	164.9	276.7	7.9	5.0
Sundry Creditors	28.2	25.5	30.8	54.4	70.9	90.4	103.9	107.1
Customer balances	7.4	6.9	3.9	3.7	9.3	25.5	27.8	41.1
Tax provisions	24.1	39.7	47.7	52.7	55.5	55.5	55.5	55.5
Unpaid dividend	6.0	11.2	8.8	10.2	11.3	—	—	—
Employees, Bonus	3.2	4.2	5.9	4.5	4.2	3.0	2.8	2.8
Others	0.2	3.7	8.0	10.0	13.0	16.5	16.7	22.4
TOTAL LIABILITIES	304.6	364.7	532.9	582.2	559.6	846.4	755.4	668.2

Exhibit 1 (Contd.)

HINDUSTAN TRACTORS LIMITED (AR)

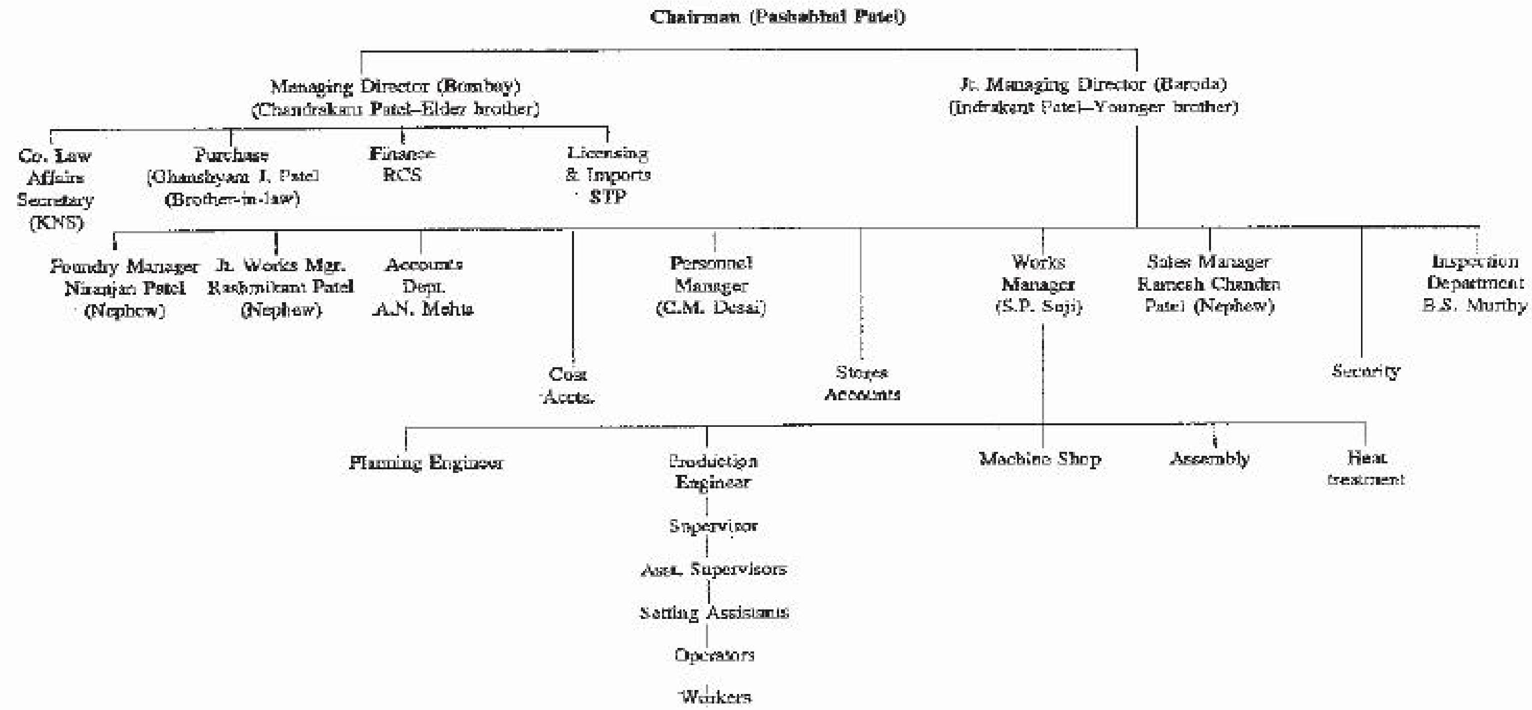
Profit and Loss Account

(Amount in Rs. Lakhs)

	Year ended March 31							
	1965	1966	1967	1968	1969	1970	1971	1972
Sales (including spare parts), net of excise	204.0	321.5	405.7	387.5	442.4	431.9	290.5	188.3
Consultation and Service	5.0	4.6	4.6	5.1	2.0	2.0	2.0	2.0
Materials consumed	137.2	227.8	318.5	267.5	349.2	361.1	246.7	155.6
Wages and Salaries	21.5	24.1	28.6	33.8	36.9	37.2	34.2	29.0
Manufacturing Expenses	6.7	5.9	9.3	13.3	18.2	20.1	14.7	12.5
Gross Profit (Loss)	43.6	68.3	53.9	78.0	40.1	15.5	(3.1)	(6.8)
Admn. & Gen. Exps.	12.1	15.0	17.5	24.6	24.7	21.5	17.6	11.2
Mg. Agents' remuneration	—	3.0	1.9	3.0	0.5	0.5	—	—
Interest	4.8	2.5	6.1	6.8	13.0	18.2	37.2	52.8
Depreciation	4.7	9.7	10.4	16.2	8.1	10.1	10.1	10.1
Operating Profit (Loss)	22.0	38.1	18.0	27.4	(6.2)	(35.0)	(68.0)	(80.9)
Donations	—	0.3	0.2	0.2	0.6	0.1	neg.	neg.
Other Income (Expense)	4.8	1.9	(1.4)	2.9	24.9	2.9	2.2	1.3
Pretax Profit (Loss)	26.8	39.7	16.4	30.1	18.1	(32.2)	(65.8)	(79.6)
Tax Provision	13.7	15.5	8.0	4.5	—	—	—	—
After-tax profit (Loss)	13.1	24.2	8.4	25.6	18.1	(32.2)	(65.8)	(79.6)
Pref. Dividend	—	—	—	2.6	2.8	—	—	—
Equity Dividend	6.0	11.2	8.4	*8.4	8.4	—	—	—
Retained Earnings	7.1	13.0	—	14.6	6.9	(32.2)	(65.8)	(79.6)

*Company swiched from written down value to straight line depreciation; excess depreciation of previous years written back was Rs. 25.3 lakhs. Depreciation for 1968-69, on the basis of written down value would have been Rs. 17.6 lakhs. Under the straight line method it was Rs. 8.1 lakhs.

Exhibit 2
HINDUSTAN TRACTORS LIMITED (AR)
Partial Organization Chart



As of 1972
* Relations to Pashabhai Patel
@ Only relative as defined under Sec. VI, Companies Act, 1956.

Exhibit 3
HINDUSTAN TRACTOR LIMITED (AR)
Hindustan's Tractor Output and Capacity

	Output		Annual Capacity (single shift) Licensed		Installed	
	50 h.p.	35 h.p.	50 h.p.	35 h.p.	50 h.p.	35 h.p.
1963-64	395	380	1000	1000	500	—
1964-65	541	1302				
1965-66	1043	370				
1966-67	1032	773				
1967-68	1192	838	5000	2000	18000	1000
1968-69	1159	832				
1969-70	1143	514				
1970-71	745	446				
1971-72	22	355				

Exhibit 4
HINDUSTAN TRACTORS LIMITED (AR)
Some Information on Various Tractor Manufacturers

Particulars	Major Manufacturers* TAFE	International	Escorts	Hindustan	
Year of production	1961	1965	1966	1963 (50 h.p.) 1965 (35 h.p.)	
Collaboration	Massey-Ferguson of Canada (equity: 49% & tech.) using Perkins engines of Simpson & Co. Ltd., Madras, a sister concern	International Harvester Co., UK, (equity, loan, and techn.)	1. Motoimport, Warszwa, Poland (tech.) for 37 h.p. using 3 cyl. air-cooled engines of Kirloskar, Poona, 2. Ford Motor Co., USA (Fin. and techn.) for 45/40 h.p.	Motokov & Zavody Jana Svermy Czechoslovakia (tech.)	
Import content (%)				35 h.p.	50 h.p.
1966	68	60	54	50	62
1969	78	67	62	50	80
Annual licensed capacity (No.)	7,000 (35 h.p.)	10,000 (35 h.p.)	7,000 (27 & 37 h.p.)	2,000	5,000
Installed capacity (No.) (1971-72)	7,000	10,000		1,000	1,800
Production				35 & 50 h.p.	
1967-68	4,087	2,901	2,556	2,646	
1968-69	3,275	4,001	5,625	2,219	
1969-70	2,818	4,403	7,833	1,661	
Growth plans		Step up to 20,000 (letter of intent)	Set up unit to make 16,000 engines on designs bought from the Polish		
Other activities of the group to which the company belong	Auto engines, pistons, etc.	Jeeps, elevators, chemicals etc.	Agri. implements, motor-cycles, pistons, railway equipment etc.	Construction and earth-moving equipment	

*In addition to those four, Eicher Tractors India Ltd., Faridabad, made about 1,000 27 h.p. tractors in 1971-72 and Hindustan Machine Tools Ltd., Bangalore, a public sector enterprise, produced 1,600 25 h.p. tractors during 1971-72 in collaboration with Motokov of Czechoslovakia.

Exhibit 5

HINDUSTAN RACTORS LIMITED (AR)

Total Availability of Tractors

Year	Production	Imports	Additions during the year	Cumulative number in use	Mortality*
1960-61	-	2,586	2,586	31,015	--
1961-62	880	2,997	3,877	34,349	543
1962-63	1,414	2,616	4,030	37,815	564
1963-64	1,983	2,349	4,332	41,540	607
1964-65	4,323	2,323	6,646	47,255	931
1965-66	5,796	1,939	7,735	53,966	1,024
1966-67	8,816	2,591	11,407	63,776.	1,597
1967-68	11,394	4,038	15,432	77,047	2,161
1968-69	15,437	12,397	27,834	100,984	3,897
1969-70	17,101	12,801	29,802	126,614	4,172
1970-71	19,535	16,679	36,214	157,758	5,070
1971-72	16,535	16,000	32,535	185,738'	4,555

Source: Demand for Tractors (Delhi: National Council of Applied Economic Research, 1974).

*Derived figures.

Exhibit 6

HINDUSTAN TRACTORS LIMITED (AR)

Tariff Commission's Estimates of Cost: 1967-68

(In Rupees per tractor)

Particulars	35 h.p.				50 h.p. Hindustan
	TAFE	International	Escorts*	Hindustan	
Estimated Production (Nos.)	4,803	2,500	1,860	800	1,800
Direct Materials					
CKD pack	5,724	3,625	4,905	9,036	7,599
Components & raw materials:					
Imported	86	2,071	—	638	1,167
Local	10,764	7,360	9,175	2,929	8,056
Materials Cost	16,574	13,056	14,080	12,603	16,856
Direct Labour	97	300	97	84	307
Factory overhead	783	1,529	542	238	953
Depreciation	346	817	84	96	553
Write-offs	51	580	18	45	452
Admin. overheads	132	64	173	80	307
Royalty	170	322	43	18	196
Total	18,133	16,678	15,037	13,164	19,714

Source: Tariff Commission, Government of India, *Report on the Fixation of Prices of Agricultural Tractors*, Bombay, 1967.

The horsepower of Escorts tractors is 37.

Exhibit 7

HINDUSTAN TRACTORS LIMITED (AR)

Prices of Various Makes of Tractors

(In Rupees)

	35 h.p.				50 h.p.
	TAPE	International	Escorts	Hindustan	Hindustan
At start of	14,450	16,380	15,400	12,500	17,500
production(Data)	(Early '62)	(Feb. '65)	(Mid '66)	(Early '65)	(Mid '64)
Pre-1966.	15,906	19,835		13,350	18,850
Post-devaluation Selling prices	20,821	19,927	17,300	17,250	23,785
(Early/Mid 1967) Tariff Commission's recommendations	20,838	20,900	19,500	16,110	21,880
(Oct. 1967)** Statutory prices***	21,270	20,230	17,690	15,680	23,370
(Mid 1968)	21,140	19,570	17,910	15,750	22,357
Sept. 1971 ,	24,190		17,470	17,470	24,900
Sept. 1972			24,100	24,100	32,900

*' Prices fixed by Government of India, based on a cost investigation by the Cost Accounts Branch, Ministry of Finance, include excise freight, expenses, and cost of the following accessories: hydraulic life, three-point linkage, power take-off, head, tail, and plough lights, tool set, and electric horn. Where any accessory was not standard, statutory rebates were to be given.

** Ex-works, consumers to be charged extra for packing, freight, and insurances, estimated at the time to average Rs. 215 for TAPE, Rs. 157 for International, Rs. 211 for Escorts, Rs. 128 for Hindustan 35 h.p., and Rs. 205 for Hindustan 50 h.p. Includes dealer's commissions and selling expenses.

*** F.O.R. destination, including packing, freight and insurance, selling expenses and dealer's commission.

Source: Tariff Commission Report, 1972, and company records.

Exhibit 8
HINDUSTAN TRACTORS LIMITED (AR)
Indigenization Targets & Achievement

Year	Target Set @ for indigenization		Achieved Indigenization	
	%* 50 h.p.	%* 35 h.p.	% 50 h.p.	% 35 h.p.
1962-63	50	—	42.5	—
1963-64	70	50	42.5	—
1964-65	80	50	42.5	17
1965-66	80	65	59.2	24
1966-67	80	50 (revised)	61.8	24
1967-68	over 90	58 (revised)	79.5	50
1970-71	over 90	Over 90	85.0	57

@ Targets set by the Directorate General of Technical Development, Ministry of Industrial Development and Company Affairs, Government of India.

* Of the c.i.f. value of a completely built-up imported tractor.

Exhibit 9
HINDUSTAN TRACTORS LIMITED (AR)
Financial Profitability of Selected Units

(Rs. in lakhs)

Particulars	International		Hindustan		TAFE		Total	
	1969-70	1970-71	1969-70	1970-71	1969-70	1970-71	1969-70	1970-71
Sales (Rs.)	967	1,356	416	264	812	976	2,195	2,196
Gross profit as % of sales	9.4	5.6	–3.3	–11.2	3.4	–5.9	4.8	0.5
Capital employed (Rs.)	902	1,142	778	686	421	538	2,101	2,366
Owned funds as % of capital employed	46	46	16	9	60	40	38	31
Gross profit as % of capital employed*	10.1	6.7	–1.8	–2.6	6.6	–6.3	5.0	0.6

* The average for all industries was 9.9 in 1969-70 and 11.2 in 1970-71.
Source: *The Economic Times*, June 24, 1972.

CASE 5

INDIAN IRON AND STEEL COMPANY

The management of the Indian Iron & Steel Co. (IISCO) in 1988-59 were actively planning the modernization of the production systems of the Burnpur Steel Works. The integrated steel plant was located in the iron and coal mining belt of Eastern India, and was one of the oldest steel making units in the country. The modernization had been ,initially proposed in 1966, by the then private sector management. However, its inability to mobilize the funds and technical expertise required for the purpose, had led to the takeover of management by the Central Government, in. 1972. Seventeen years after the takeover, the modernization proposals were being pushed through the various layers of Government bureaucracy.

Mr. M.P. Mehta, Managing Director, IISCO, was contemplating the changes the proposed modernization would bring about. Apart from production the changes speared to cut across other functional areas as' well-viz., finance, personnel, marketing and control systems.

Corporate Structure of IISCO -Historical Evolution

The Indian Iron & Steel Co. Ltd. was incorporated as a Public Limited Company under the Indian Companies Act, 1913. Registered on the 11th of March, 1918, and promoted by the Managing Agency, Burn and Company, it had an authorised share coital of rupees throe crores. IISCO initially operated an iron making plant of 480,000 MT/Yr. capacity, at Hirapur village, near Asansol in. West Bengal. Coal was purchased from the collieries run by the Bengal Iron and Steel Co. which operated an iron making unit at Kulti, nearby. The Gua iron ore mines was established in 1919, to feed the Hirapur Works. IISCO commenced iron production in October, 1922. (Note: Coal and Iron-ore are the primary raw material for iron making.)

Burn & Co. sold its share in IISCO, and its other managed companies, in 1924, to the managing agents, Martin & Company. This decision by Burn & Co., was apparently taken due to the financial problems created by the world-wide recession in the iron and steel trade. The new managing agents kept the name of Burn alive, by rechristening themselves, Martin Burn & Co. Ltd.

The government reported the scope for setting up a second steel works in the country, in 1934. (The first was the Tata Iron & Steel Co. Works at Jamshedpur, established in 1907.) Martin Burn & Co. decided to actively pursue this idea. Due to a Privy Council litigation in 1921, there was a profit sharing agreement between IISCO and Bengal Iron & Steel Co. To ensure viability in opcratiolis, IISCO absorbed the latter Company in December, 1936. IISCO now came to own two iron making units at Kulti and 'Hirapur, with an aggregate iron making capacity of 850,000 MT/Yr., and 100,000 MT of castings for pipes. The collieries were augmented by the purchase of the Chasnalla coal mines. There were now also two captive iron-ore mines at Gua and Chiria.

Martin Burn & Co, then incorporated the Steel Corporation of Bengal Ltd. (SCOB) on 20th April, 1937 to produce steel. The SCOB had share capital of Rs, 5.03 crores, and installed a 250,000 MT/Yr. steel making plant at Napuria, adjacent to the Hirapur Works. Steel production commenced in November 1939.

IISCO supplied the entire hot metal (iron) requirements of the Napuria Works. These inputs were provided at cost plus small profit margin, and in return, IISCO received 20% of the profits made by SCOB. IISCO also subscribed to 11000 shares (2% of share holding) of SCOB.

The Government of India, approached the World Bank in 1952 for financial assistance for making steel. The Technical Mission of the Bank recommended that "the cheapest and quickest way to increase iron and steel production in the country would be to merge IISCO with SCOB and then expand." Further expansion in capacity for SCOB/IISCO were then made conditional upon the merger of the two companies by the Central Government.

The Central Government later promulgated The Indian Iron & Steel Companies Ordinance in 1952, which provided for the amalgamation of SCOB with IISCO. The amalgated company was known by the name of IISCO, all assets/liabilitics of SCOB being transferred to IISCO. The Hirapur Works making iron, thus merged with the Napuria Works making steel to forth the Burnpur Works of IISCO. The Burnpur Steel Works thus became an integrated iron & steel plant, with captive raw material bases. This was the third such in the country after TISCO (1907) and Mysore Iron & Steel Works (1936). The managing agents continued to be Martin Burn & Co., with one Director on the Board, being nominated by, the Central Ciovernment.

This case was prepared by V Rangarajan and Sri Ananthanarayana Sarnia with the cooperation of the executives of IISCO under the guidance of Dr. B.L. Maheshwari of the Centre for Organisation Development, Hyderabad. The case is designed to be used as a basis for class discussion rather than to illust ate either effective or ineffective handling of an administrative situation. Used with permission.

The installed capacity of Burnpur Steel Works was expanded to 700,000 MT/Yr. of saleable steel in 1955 and 800,000 MT/Yr. of saleable steel in 1961 (i.e., 1,000,000 MT/Yr. ingot steel). The authorised share capital of IISCO was increased to Rs. 14 crores in 1956, and further to Rs. 16 crores in 1959. At this till, Kulti Foundry Complex had an installed capacity of 63000 MT/Yr. castings, and 166,000 MT/Yr. spun pipes.

IISCO and M/s. Stanton & Stevely Ltd. of the United. Kingdom, jointly promoted the Stanton Pipe & Foundry Co. Ltd. to manufacture spun iron pipes and specials. The company was incorporated in July 1964, with share capital of Rs. 3.21 crores. The production unit was located at Ujjain in Madhya Pradesh, with installed capacity of 60,000 MT/Yr. pipes. Trial production commenced in August 1967.

Nationalization

IISCO drew up a Rs. 23.2 crorc plan to develop Chasnalla Collieries in 1964. The authorised share capital was increased from Rs. 16 crores to Rs. 40 crores in 1967, presumably to fund this project. A proposal to increase steel making capacity by 300,000 MT/Yr. was accepted by the Central Government, in 1966. The proposal costal the scheme at Rs. 16 crores with a foreign exchange component of $16 Million, $9 Million was budgeted for essential spares and replacements. The World Bank agreed to fund the dollar part. The grant of import licenses was however delayed by the Central Government, by three years. As the import licenses had not materialised within the stipulated time, the World Bank cancelled its loan, By 1970, the cost of renovations had increased to Rs. 20 crores, and that of expansions to Rs. 27 crores.

In April 1970, the managing agency system was abolished, which left IISCO bereft of the support of Martin Burn & Company. Martin Burn then, was the third largest industrial group in the country, in terms of assets, after the Tatas and the Birlas.

In the late sixties, labour militancy became endemic in Eastern India, produeuon declined and labour costs increased for IISCO. The Chasnalla project had a cost overrun of Rs. 17 crores. The rupee devaluation of 1967, put an additional burden of Rs. 8.4 crores on IISCO. The pricing of steel products was regulated by the Central Government, which did not see such reasons as basis for price increases. Thus by 1971-72, the amount of loan repayments stood at Rs. 35.04 crores. The Central Government refused to allow rescheduling of debts. The share of IISCO plunged below par in August 1971.

The Central Government decided to take over the management of IISCO "for a limited period of two years in the public interest to secure the proper management of the undertaking". An ordinance in July 1972 was passed for this purpose. The. Union Minister of Steel, while piloting the takeover bill in Parliament, stated the major reasons' for the takeover to be:

i) steady deterioration in plant condition

ii) serious industrial relations situation

iii) need for professionalising the management

iv) urgings made by a section of the Board.

The Indian Iron & Steel Company (Taking over of Management) Amendment Act, 1974, allowed for the undertaking of the Company to vest in the Central Government for a further period up to a maximum of ten years. In 1976, the Central Government held that the top management of the Company was guilty of mismanagement of the affairs of the Company, and restoration... of the management of the affairs of the company to such top management would he prejudicial to the interests of the Company and to public interest. Also, "investment of a large amount is necessary for the maintenance and development of the production of the undertakings of the Company"... for which.., "acquisition by the Central Government of an effective control over the affairs of the Company is necessary to enable it to make the (aforesaid) investments". The Indian Iron & Steel Company (Acquisitions of Shares Act), 1976, was enacted to provide for the acquisition of all shares 'of IISCO held by the public. In December 1977, the authorised capital was raised from Rs. 40 crores to Rs. 100 crores.

The,Public Sector Iron & Steel Companies (Restructuring) and Miscellaneous Provisions Act, 1978, provided for all public sector steel plants to come under the purview of the Steel Authority of India Limited (SAIL), which was termed as an integral company. All the shares of IISCO held by the Central Government, were now vested with SAIL. IISCO thus became a subsidiary of SAIL. However, it continued to retain its status as a' separate company under the Indian Companies Act, and had its own Board of Directors. In November 1985 the authorised share capital was increased to Rs. 150 crores and further to Rs. 550 crores in September 1988, the subscribed share capital stood at Rs: 273 crores, which was all held by SAIL or its nominees.

The IISCO Stanton Pipe and Foundry Company continued to retain its identity as a separate company after nationalisation. The public sector British Steel Corporation of the United Kingdom acquired the Stanton &

Stavely Limited, and decided to divest of its shares in the Company. The shares were bought by IISCO in 1983-84. The IISCO Stanton & Pipe Foundry Company was now a fully owned subsidiary of IISCO.

Thus in 1989, IISCO, a subsidiary of SAIL, had the following units under its control:

1) Burnpur Steel Works, with installed capacity of 1 Million MT/Yr. of Ingot Steel.

2) Kulti Foundry Complex, with installed capacity of 63000 MT/Yr. castings and 166000 MT/Yr. C.I. Spun

3) Pipes.

4) A fully owned subsidiary Stanton Pipes & Foundry Company, with installed capacity of 60000 MT/Yr.C.I. Spun pipes- .

5) Collieries at Chasnalla, Jitput and Ramangore & Coal Washery at Chasnalla.

6) Iron-ore mines at Gua and hiria.

Exhibit No. 1 gives us chronology of the major events in IISCO.

Burnpur Steel Works -Description

The Burnpur Steel Works is the most important unit of IISCO. The fortunes of IISCO had always been tied to that of the Steel Works. More than three-fourths of IISCO's turnover is directly accounted for by the sale of steel, scrap, and by-products of the Burnpur Works-Rs. Rs. 413 crores on a turnover of Rs. 497 crores, in 1987-88. Similarly, a little more than half of all employees of IISCO are employed inside the Burnpur Works - around 17,000 out of a total of 35,700. The plant is located about 200 kms, from Calcutta and is about 10 kms. off Asansol Railway station on the main Howrah-Delhi railway line.

The main physical entry to the plant is through a tunnel gate. Immediately emerging from the tunnel, a visitor cannot fail to be overwhelmed by the panoramic setting of the Works. A treelined avenue, flanked on either side by the still waters of the cooling pond; in the background stands giant cooling towers, alongside the various Works units,

(Pages' No. 26-28 detail the production process and the machinery at the Works)

The Burnpur Works has spawned the Burnpur township - which houses mainly plant employees. The township contains around 900 executive houses and 6,500 non-executive quarters. The township department of the Works maintains five playgrounds, a market, and runs a bus service for the school children. Beyond the township lies the Nehru Park and the aerodrome. There, the aviation department has aviation overhaul shops, which are approved by the Director General of Civil Aviation (the only one to get the approval amongst all the aviation shops of the SAIL steel plants). The township also has a 480 bed hospital, staffed and run by the worlds,

The highlight of the township is an area named 'the ridge'. The Ridge contains colonial mansions, which houses top executives. Amidst these houses, nestles the luxurious Burnpur guest-house --- which is described as the best of the guest-houses maintained, by the steel plants of SAIL. Alongside the guest-house, is the Managing Director's office- which was previously the Director's bungalow. In colonial times, (when the plant was run by Europeans), as the saying goes, only white skinned people were allowed to walk along the Ridge roads'.

Organizational Analysis

For the analysis of the organization, the°7-S model, developed by McKinsey & Co, has been used. The model assumes that executives have only a limited number of 'levers' to influence complex large organizations. The model explores the seven major ones: superordinate goals, strategy, structure systems, skills, style and staff.

Though there could be more variables than seven, these are presumed to be of crucial importance. Ttie model is to help the executives develop a more effective way of perceiving and cutting through the complexity of organizations. The framework is illustrated on page 13.

The central point of the model is that the FIT among the seven variables has to be good to get long-term leverage. Addressing oneself to one or two of the S's is generally not sufficient. Even if the manager is aware of the need to work at adjusting the fit of the rest of the S's after a significant change in one or two (say, strategy and structure), it is certain to take effort and time to achieve integration.

Among the 7S's strategy, structure and systems are perceived to be the hardware and the rest-skills, style, staff and superordinate goals to be software.

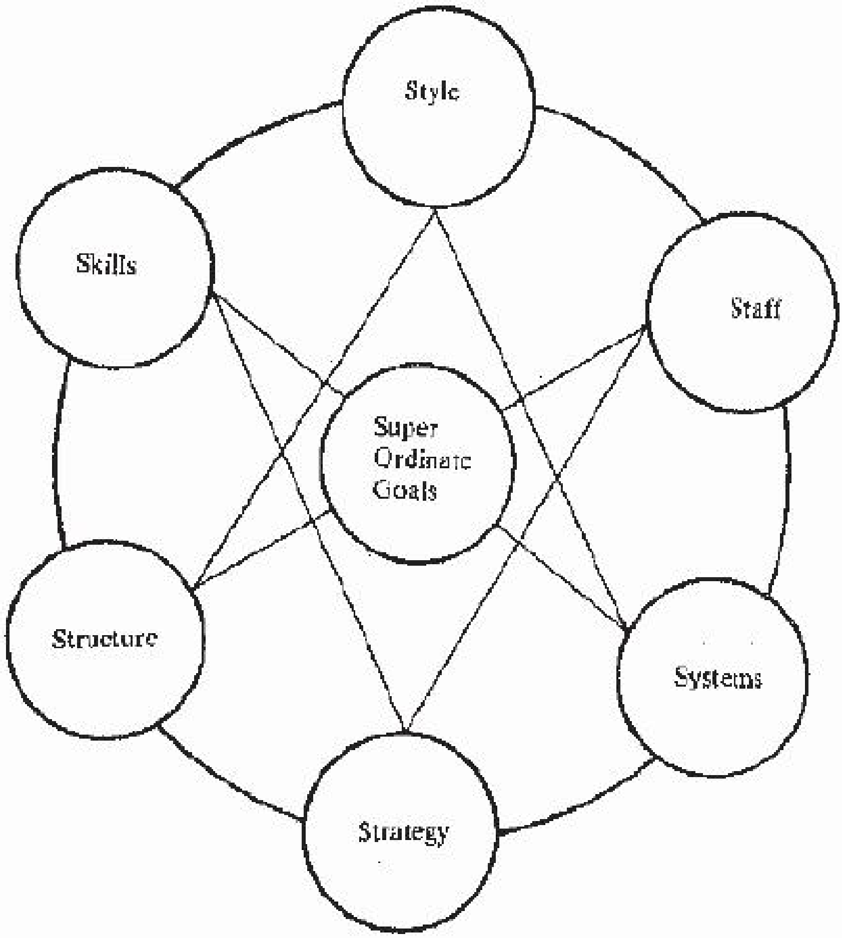


Table I The 7-S Framework

The superordinate goal is the lever which integrates the functioning of the other 'S's. Hence the presentation of the information relating to the organization begins with superordinate goals.

Superordinate Goals

Superordinate goals are shared values and aspirations that go beyond quantified objective, such as profit, ROI, etc. While these might include simple goal statements, the values must be shared by most people in an organization.

Before the nationalization, the plant- had a "Europeanized" sense of values, with the top management being Europeans. Sons of employees were given preference in employment. This led to three generation linkages from individual families, with the Works, enhancing the feeling of belongingness. Stability at the top level, led to a team spirit and discipline which contributed to high productivity (consistent achievement of capacity utilization). Therefore, IISCO had a good corporate reputation. It was the only Indian company quoted on the London Stock Exchange. It paid 17% dividends in the 60s. However, these shared values were perhaps built on a "fear of authority" and the assumptions of racial superiority. The labour militancy in East India in 1967, overturned these values - anarchic acts of sabotage and personal humiliation, which made top executives quit, resulted in a sharp deterioration in performance.

Subsequently, the nationalization brought in a new 'public sector' culture. Senior executives of the Works, who witnessed the transition, explained that with this public sector culture, there was an increase in the number of levels, authority was no longer feared, poor work rarely got punished, rules and procedures were given more importance than getting work done, and staff functions like personnel, finance and materials grew in size. Staff functionaries acquired greater power on the 'Control' function.

The high turnover of the top executives (sec Exhibit-II) appears to have contributed to dilution of autonomy and uncertainty in decision-making. The emphasis had shifted to 'doing things right' from `doing the right things'.

The Works has been continuously making losses after nationalization with low capacity utilization and improper maintenance.

SAIL (the public sector parent organization) has initiated the modernization strategy to reverse this trend. SAIL itself had experienced financial problems until 1985. The new Chairman, Mr. V. Krishnamurthy, introduced a new work culture in all SAIL units, which emphasized bettor customer service, achieving rated capacity and reducing energy costs. Overtime payments were stopped from 1987. The SAIL plants have reported continuous increase in production (15% from '88-'89) and SAIL expects to wipe out its cumulative losses of Rs. 300 crores this year. The Chairman has also initiated a Rs. 15,000 crore modernization programme, to be funded by internal accruals and non-govt. borrowings which seeks to double steel production and labour productivity. One part of this programme is to spend Rs. 3,000 crores to modernize the Burnpur Works, and increase its rated capacity from One Million MT/Year to 2.15 Million MT/Year.

The SAIL Corporate Planning Director had, in a press interview, expressed the hope that after modernization "Burnpur could become the model plant for SAIL".

Strategy

Strategy is defined as a distinctive product-market-technology choice made by an organization and the mode of its implementation. This 'set of actions' made be aimed at giving a sustainable advantage over competition (say, providing better service to consumers) or allocating resources.

The initial decision of IISCO to get into steel production was due to the strategic compulsion of finding markets for the iron produced by it. The company (IISCO) had considerable iron .production capacity and stable operation could only be achieved by means of an increase in the off-take of iron within India. In the absence of a large demand to absorb the entire iron output, its conversion to steel and rolled products was considered as the most logical and the only option. With these considerations in view the Steel Corporation of Bengal Limited was incorporated on 20th April, 1937, with Burn & Co, as the managing agents.

The depression of the thirties produced a cartel arrangement between the major producers i.e., TISCO, IISCO and Mysore Iron Works, to fix prices, regulate output and allocate markets. During the War years (1935-45) the Government exercised informal price control on steel products for war requirement, From July'44, the controls were widened to cover civilian requirements and prices were fixed by the Government. However, the Government ensured that opportunities were provided for maximising production and profits. The price controls were withdrawn after the war - the steel capacity of the works was increased to 350,000 MT/Year (ingot steel) in 1946 to meet the post-war boom in the market.

The Technical Mission of the World Bank which visited the country in 1952, at the invitation of the Government, estimated the gap between supply and demand in the country to be around two million tonnes of steel and 400,000 tonnes of foundry iron. One of the strategics suggested by the World Bank team to meet this gap was to expand the existing units.

As mentioned earlier, the Government then ordered, the merger of the steel making unit of SCOB with the iron-making unit of IISCO forming the present Burnpur Works and expansion of productior, capacity of steel. The 1953 expansion increased the capacity of the plant to 700,000 MT of saleable steel and 400,000 MT of foundry iron. The 1955 expansion further increased production capacity to 800,000 MT of saleable steel (1 Million MT of ingot steel) and 260,000 MT of foundry iron,

In the early 60s steel production in Burnpur Works touched 90% of the rated capacity, Full capacity utilization was reached in 1963-64. This compared favourable with the then prevailing norms in the steel industry, when 60% capacity utilization was accepted as optimum achievement in the initial year of operation. The period from 1960 to 1967, also saw IISCO consistently outperform TISCO (its major steel making competitor) in the share market.

As mentioned earlier, a combination of political, financial and labour problems led to the takeover of company management by the Government in 1972 and the subsequent nationalization, The capacity utilization in that year (1972-73) was only 43%.

One of the reasons for nationalization, given by the Government, was to ensure the renovation and modernization of the Works. The low capacity utilization, was due in part to the fact that foreign exchange required for urgently needed spare parts had not been sanctioned.

However, the Government/SAIL continued to neglect this aspect of ensuring proper maintenance of the plant, after the takeover. The Burnpur Works has, since the takeover, never crossed 70%: rued capacity utilization, and has consistently reported losses.

Modernization of the plant had been the major strategic concern since 1966. The first attempt made by Sir Bunn Mukherjee (then Chairman of the Private Sector IISCO) to get a World Bank loan to fund a modernization programme did not receive support of the Government.

After the takeover, the Government carried out a plant rehabilitation scheme as a temporary solution to the modernization problem. M/s M.N. Dastur was appointed in 1977 to carry out a feasibility report. They estimated the modernization cost to be around Rs. 300 crores, with a new sinter plant, shifting from open hearth furnaces to basic oxygen furnaces and using L.D. convertors instead of Bessemer convertors. This report was however not followed up.

When the Prime Minister, Mrs. Indira Gandhi visited the Soviet Union in 1981, she accepted a Soviet offer of a feasibility study for modernization of Burnpur Works. The Soviet modernization report, submitted in 1983, estimated that Rs. 933 crores would be required to maintain the plant at one million MT capacity. The second phase was to increase the capacity to 1.6 million MT/Year and the third phase to 3 million MT/Year.

Shortly afterwards, both the Managing Director of IISCO and the Steel Secretary of the Government of India, changed, and the proposal was dropped.

The latest attempt at modernization was initiated when the Prime Minister, Rajiv Gandhi visited Japan in 1985. At his request, a Japanese consortium of five major Japanese steel producers came to India and submitted the feasibility report in 1987, through the Japanese International Corporation Agency (JICA).

The Government/SAIL accepted in-principle to plan ahead for modernization on the basis of this feasibility report. The final cost proposal is expected to be submitted for approval to the Public Investment Bureau (P.I.B,) of the Government in late 1989.

The major highlights of the JICA report are:

i). scrapping of old and building of new blast furnaces and the steel melting shop;

ii). building of sintering and continuous casting facilities and one new Coke Oven Battery with simultaneous phasing out of another Coke Oven Battery.

iii). revamping of some of the existing rolling mills and adding two new bar mills.

The total cost is estimated at Rs. 3000 crores, of which Rs. 1000 crores is in foreign exchange, (to be met through loans from Japan at concessional rates of interest).

The modernization strategy has become crucial to ensuring the existence of the plant. At present, the Works is operating on vintage technology. A blast furnace installed in 1920 is still in operation. Steel making processes like the Duplex with Bessemer convertors and open hearth furnaces have been phased out by other steel plants in the world a long time ago. Lack of pre-treatment facilities has seen high raw material consumption;

All this has led to financial unviability - The Burnpur Works has continuously reported losses after nationalization. A comparison of the cost of saleable steel production figures for SAIL and for the Burnpur Works is presented below for illustration.

Table II Cost of Production at SAIL & IISCO (Saleable Steel) (1987 88)

(Source: Figures of annual cost have been quoted from the Annual Report of SAIL for the year 1987 88, as reported in the Economic Times, Bombay -- May 10, 1989, page five; and the Annual Cost Sheet of IISCO, Burnpur Works for 1987-88.)

		SAIL		IISCO,BURNPUR	
	ITEM	Total Cost (Rs, Crores)	Cost/M.T (Rs.)	Total Cost (Rs.Crores)	Cost/M.T (Rs,)
1)	Raw materials	1704	2315	196	3612
2)	Stores & Spares	788	1071	23	420
3)	Salaries &	715	971	68	1251
4)	Power & Fuel	468	636	43	789
5)	Freight/Repairs				
	Misc. Expenses	370	503	38	696
		4045	5496	368	6768

Note: Preduaton of saleable steel (including pig iron) in 1987-88 was 7.34 million MT as per Annual. Report for SAIL and 0.54 million MT of Saleable Steel for IISCO.

There are four strategic options open for the Burnpur Works at this stage:

1) Shut down the plant.
2) Only renovate the existing units - without adding new equipment.
3) Totaly modernize - Build a new (greenfield) modern plant and scrap all old facilities.
4) Choose a hybrid route of partial modernization (bringing in new equipment) and partial renovation of old facilities.

As a senior executive pointed out:

The first option of closing down the plant would mean that the 35,000 odd workers and families who directly or indirectly depend on the Works for their livelihood would be unemployed - This would create serious social problems in the township of Burnpur. The Left Front Government of West Bengal would exert a lot of political pressure on IISCO/SAIL against this decision. Also, the Works is strategically located in the coal/iron-ore mining belt and has in the past been one of the best run plants in the world. Given SAIL's inherent strength in steel technology, this alternative has not been chosen.

The second option of only renovating existing units would mean that the Works is stuck with the existing old technology. The blast furnace and steel melting shop equipment is obsolete. The increases in coal and oil prices and in wages, has made steel-making a loss-making proposition with existing technology. The Government/SAIL may not be prepared to continue underwrite losses of the Works. Hence the unviability of this option.

The third option of building a new plant (of a comparable 2.15 Million MT capacity) would cost Rs. 6000 crores as against the cost of Rs. 3000 crores of updating the existing plant. Two coke ovens have been rebuilt already, and are practically new. It makes no sense to throw away such equipment. Also many of the infrastructural facilities and some of the mills can be run profitably. Thus, this alternative has not been pursued.

Therefore, the fourth option of scrapping and rebuilding obsolete equipment and using some of the existing facilities has been chosen, which forms the basic strategy of the modernization proposal submitted by JICA.

Modernization Programme - Salient Features

Marketing: The JICA feasibility report based the modernization proposal on the SAIL forecast of the steel market in India up to 2000 A.D. The demand for Bar Mill products is expected to exceed supply in India by 870,000 MT in 089-90 and increase to 3.63 Million MT in the year 2000. Hence bar mill products were chosen for capacity expansion and two new bar ad section mills (with a capacity of 1.3 Million MT/Year) are proposed.

The other option of producing hot coils was discarded due to uncertain market arid heavy capital investment.

Provision for erection of facilities for producing high value added items like low alloy steel grades is being kept for future additions.

SAIL decided that Burnpur Works would continue to produce only long (non-flat) products - Hence the modernization package does not envisage new facilities for producing flat products. (Nose: Saleable steel is usually classified as long or flat products.)

The steel products after modernization are expected to be internationally competitive in price and quality.

Production Facilities

Some of the units like coal yards, coal handling plants, two coke ovens (Nos. 8 & 9) and part of rolling mills are to be retained under the proposal.

The following units are to be scrapped:

a) Two coke ovens (Nos. 7 & 10),
b) The four blast furnaces,
c) The steel melting shop (which uses the Duplex process)
d) light structural' mill and
e) sheet mills

The following units arc to be introduced into the works:

a) One 92 oven, coke oven battery (No. 11)
b) Two sintering machines,
c) Two blast furnaces,
d) Three basic oxygen converters with Oxygen Plant,

e) Four continuous casting machines - one Bloom Caster and three Billet Casters,

f) Two new Bar mills, and

g) New captive Power Generation facilities.

(See Exhibit - III for further details).

Raw Material: The JICA proposal does not cover the coal and iron-ore mines, Modernization schemes are being currently taken up to ensure that raw material of specified quality and quantity are available after modernization.

The Coal Washery at Chasnalla is being modernized and the Chasnalla deep mines reopened for mining in 1992 -- this was stopped after a mining disaster in 1975 which claimed 375 lives.

The iron-ore mines are expected to produce adequate iron lump & fines that will be required for the Burnpur Works after their modernization. A new coal yard is to be constructed and raw material preparation facilities are to be installed.

Finance: The total cost of modernization was estimated at Rs. 3000 crores. This cost has now increased to Rs. 3800 crores due to yen appreciation and duty increases from 55% to 80% (duties amount for 20% of the cost). The foreign exchange part is to be funded by a 20 year loan, with a ten year moratorium and 5% rate of interest from Japan. The rupee amount is to be funded by SAIL, through its internal accruals, loans from the Steel Development Fund (carrying 8% interest) and selling of bonds.

One. of the preconditions that has to be met for ensuring viability of the modernization programme is that accumulated losses (about Rs. 470 crones as on 31.3.89) and expected losses till production commences after modernization (1995) are to be absorbed by the Government/SAIL.

Time: The start-up date for the modernization programme is 21st July, 1988. The project is expected to be completed in 7 years and 9 months. By late 1989, the final approval for the programme is expected from the Government. The modernization will be carried out on a turnkey basis by the Japanese. The levelling work at the new site is already in progress. (See Exhibit- IV for Schedule of modernization.)

The modernization is expected to be completed in two phases. In Step-1, one million MT/Yr. capacity will be reinstalled, (1993) and in Step-2, full capacity of 2.15 million MT/Yr. crude steel will be installed, (1995).

The existing production processes are to continue operation - A phasing out programme has been drawn up to synchronize the phasing out of old units and introduction of new ones. (See Exhibit-V).

The Major Advantages of Modernization

1) In the by-product facilities, after modernization; (i) Coke oven gas will be doubled. (ii) Coal Tar will increase from 25,000 tonnes to 70,000 tonnes, (iii) Crude Benzol will increase from 3200 cubic metres to 12,000 cubic metres (iv) Ammonium Sulphate from 2300 tonnes per year to 4200 T/Yr.

2) In the main iron and steel works, (i) Man-power will be reduced from the existing 21,671 to 14,134 employees. (ii) The production will be four times more than the present production. (iii) Energy usage be reduced from 16 calories to 7 calories per tonne of steel, which will bring down the energy cost. (iv) Cost of manufacturing will be reduced to half and (v) The plant is expected to operate at 100% of its rated capacity. The following table reproduces the major features.

Table III Major Features of Modernization

	New Plant	Existing Plant
Rated capacity/Annum	2.15 Million tonnes Crude Steel	1 Million tonne Ingot Steel
Power requirement	116 MW.	30 MW.
Production of Hot Metal	Rs. 1593 per tonne.	Rs. 2571 per tonne
Consumption of Coke per tonne of hot metal	589 kg.	1000 kg.
Slag generation per tonne of hot metal	460 kg.	700 kg.
Productivity of blast furnace per cubic metre	1A1 tonneM'/day	0.78 tonnesM'/day
Cost of Ingot Steel Production	Rs. 2645 per tonne	Rs. 4832 per tonne
Production Process	130 tonnes in 50 minutes with 13OF technology	250 tonnes in 10 hours with open Hearth Furnace
Cost of Production of Saleable Steel	Rs. 3117 per tonne	Rs. 6768 per tonne

The new technology calls for new skills. Instead of the present `Duplex process' the `Basic Oxygen Furnace' technology will be used for steel-making. The coke rate which shows blast furnace efficiency is 749 kg. per tonne for SAIL. In Japan and South Korea it is around 450 kg. per tonne. In IISCO after modernization it will be at 589 kg. per tonne. The total revamping of technology will see a quantum jump in skills.

Kulti and Ujjain Works

The Kulti and Ujjain Works did not figure in the Japanese modernization programme. A seperate modernization plan was expected to be undertaken for the casting shop in Kulti by SAIL. The casting unit had evolved into an inhouse foundry for the steel plants of SAIL. Its production was 51,749 MT in 1987-88 (80% capacity utilization).

The production at the spun pipe plant at Kulti was 54,265 MT in 1987-88 (33% capacity utilization). The production in the Ujjain spun pipe unit was 32,369 MT in the same year (55% capacity utilization). One of the major reasons for under utilization of spun pipe capacity was the declining demand for the product. The major consumers of spun CI pipes were Government and Semi-Government agencies. These pipes were used for water supply and drainage schemes. The introduction of PVC, asbestos, and prestressed concrete pipes had whittled down the share of spun pipes in this market. In view of the uncertain demand, IISCO had not firmed up modernization plans for the spun pipe-units.

Structure

Structure is formally represented by organization charts. It includes reporting relationships, and details how tasks are both divided up and integrated.

Organization structure in the `good old days' as reported in the `History of IISCO' "in the twenties, at the Hirapur Works, (producing iron) ... The works were divided into 13 main departments, each with a departmental manager responsible to the General Manager. Eight were convenanted Europeans, while five' were Indians, who managed the 13 departments. Each department had a foreman incharge and below him were several rungs of labour. Selection of the European staff was by the agent in England, while the General Manager at Burnpur engaged the Indian staff. While no organized training department appears to have existed in the early days, on-the-job training was imparted by European staff and resulted in the development of a very efficient subordinate supervisory staff. Promotion was strictly accorded on merit. Relations between the rank and the file were good. Foremen usually dealt with all labour problems at the shop floor level, though labour could approach the managers, but seldom did. There was no Works Committee. It has been stated that no employee organization existed to the knowledge of the employer and that there had never been any strike or any dispute." (Page No. 49)

The General Manager of the Works, in, turn, reported to the Chairman-IISCO, who was elected along with other Board members by the shareholders. The day-to-day control of operations at the Works thus vested with the General Manager.

The takeover of 1972 brought the unit under Government control. The staff departments grew in size - the finance department gaining a lot on control functions of other departments. The Government appointed Custodian Chairman, to preside over the Board of Directors of IISCO, and continued to leave operational control of the Works to the General Manager (Works).

When IISCO became a subsidiary of SAIL in 1978, the Chairman of SAIL became the Chairman of the Board of Directors of IISCO. A new designation, Managing Director, was created. This positions was vested with operational control on all units of IISCO. The M.D.'s office was located near the Burnpur Works - effectively making the Managing Director, the operational head of the Steel Works. The Kulti and Ujjain unit General Managers also reported to the Managing Director, instead of the Chairman. The corporate identity of the Ujjain unit (USCO-Stanton pipe company) was however maintained, and the Managing Director-IISCO was made the Chairman of the company. The General Manager (Works) of the Burnpur unit reported to the Managing Director --which saw a dilution of the responsibilities associated with this post.

Exhibit-VI gives the present organizational chart of IISCO. As can be seen from the, chart, all the departmental heads report directly to the MD - The Kulti & Ujjain units and the mines/collieries, are also treated as departments for operational purposes. The span of control at the Managing Director level is 16. The top organization chart looks flat.

The overall control over the functional area is with the functional heads. There are ten levels in the executive cadre and the hierarchy looks pyramidal. The structure- is functional, which has led to specialization of skills and has not developed people in. general management areas.

From 1987 the project department has been headed by an Executive Director, Before 1972, it is headed by a project engineer, and then by a General Manager up to 1987. The change had taken place due' to modernization,

After the Government, takeover lack of stability is noticed at Managing Director level and at the level of GM (Works), Burnpur.

Before 1972 Sir Biren Mukherjee was the Chairman for almost four decades. Between 1972-83, (in a decade) 7 MDs had changed in IISCO. The lack of stability and short tenure of MDs had delayed the modernization process. The earlier attempts to modernize the plant did not come through, because of the lack of stability at the top level.

The present MD, Mr. M.F. Mehta is the first person to have a tenure long enough (from 1983) to carry out modernization.

At GM (Works) Burnpur level, Mr. J. McCraken was there for 20 years from 1951 to 71. After 1972, as many as

11 GMs have occupied the same position in less than 20 years with the longest tenure being three years. The short tenure of top executives led them to achieve short-term results, neglecting the plant in the long run.

Exhibit-II lists the Chief Executives of IISCO & Burnpur Works since its inception.

The present organization structure can be described to be a `functional' one. Some of the advantages of this structure are:

1) allows specialization
2) allows economies of scale
3) minimizes duplication of personnel/equipment
4) employees are allowed to speak the same language as their peers which makes for comfortable & satisfied employees.

Some of the disadvantages associated with this structure are:

i). Sub-unit conflicts (finance/materials/production for instance) which leads to goal displacement,
ii). Dilution of accountability as no one unit is accountable for end result.
iii). Difficulty in coordinating within units.
iv). Inability to cope with large size
v). Fails to develop general management skills.

The alternative methods of viewing the restructuring of IISCO are as under:

1) Restructuring can bring about changes by divisionalisation. Today the support functions are centralised. As part of restructuring, each zone, e.g. Coke Oven, Blast Furnace, Steel Melting shop and Mill$, could be made relatively,.autonomous. This can be done by providing them with full functional support in the areas of personnel, technology, quality, commercial safety, finance, material and maintenance.

   In British Steel, this system is called the `Ship System' where each zone is provided with all the resources and then held responsible for performance. This improves accountability and gives role clarity. Each zone can be considered as a separate profit centre.

2) The other alternative is that if IISCO is merged with SAIL, the Burnpur Works becoming one of the units of SAIL. The Collieries and mines may be taken over by the Raw Material Directorate which is taking shape at the corporate level (at SAIL). Kulti and Ujjain can be merged together and made a separate unit. The marketing department can be integrate with the Central Marketing Organization of SAIL. This will lead to lot of new positions being created, and existing ones being abolished. The power equilibrh m will change.

Major structural changes can thus be seen to be a part of the modernization programme,

Systems

Systems relate to organizational mechanisms that enable organizations to get things done from day-to-day. They include manufacturing processes, information systems, and other managerial support mechanisms like budgeting systems, performance appraisal, etc.

Finance: The major preoccupation of the pre-nationalization days was the management of the financial systems. IISCO as a public limited company had to supply detailed financial statements (Balance Sheet & Profit & Loss Account) to the Registrar of Companies and to its shareholders. The financial systems hence evolved to perform these functions. With IISCO continuing to maintain its corporate identity after nationalization, the financial systems, have not changed in design. New financial control system for ensuring compliance with public sector norms/regulations of decision-making have, however, been added. (Strengthening of audit systems/stricter verification of stock consumption/accounting/tighter tendering rules for purchase decisions.) A daily profitability statement for each shop has also been introduced. (See Exhibit-VII for specimen.)

Thus presently, separate Balance Sheets, and Profit & Loss Accounts are presented yearly for the IISCO, which includes the Burnpur Works, the Kulti Units and Mines/collieries,

The IISCO-Stanton Pipe & Foundry Company at Ujjain presents a separate set of the financial statements having retained its own corporate identity. Thus Ujjain unit accounts are not included in the IISCO financial statements. (Exhibit-VIII gives a five year summary of the IISCO financial figures.)

The accumulated losses of IISCO up to 1988-89 are around Rs. 709 crofts. A Government loan of Rs. 239 crores

is expected to be written off, giving a total loss figure of Rs. 470 crores. In practice, the working capital (cash) shortages are funded by SAIL - In a sense the Rs. 470 crores can be treated as a loan from SAIL (depreciation charges amounting about Rs. 226 crores should be excluded for exact figure). A proposal is afoot to convert this loan to equity (with a matching cash grant being made available to SAIL by the Government).

Uneconomical units are being gradually phased out from Oct. 1988, and the loss for the year 1989-90 is expected to be around Rs. 70 crores. Of this, the Burnpur Works is expected to contribute 50%. From 1989 to 1995, the annual cash losses (including interest on bank loans, excluding depreciation) is expected to be underwritten by the Government. IISCO thus expects to start with a clean balance sheet after modernization. IISCO's after modernization, is expected to produce profits from the first year of operation.

Marketing

IISCO has a separate marketing department named as the Central Sales Organization, (CSO). CSO has a good customer service record. In the past, whatever could not be sold by CMO - SAIL was sold by CSO. CSO has 8 stockyards at Burnpur, Calcutta, Madras, Bangalore, Ghaziabad, New Delhi, Ludhiana and Bombay. Its products vary in cost from Rs. 6 a tonne (or air cool slag) to Rs. 13,000 a tonne (of Galvanised Sheet). Selling of scrap is done by Central Sales Organization with its own pricing. It is important to note that the pricing for all other iron and steel items are fixed by the Joint Planning Committee (JPC), which comprises representative from the Ministry of Steel, Railways, (which is also a major customer) and representatives from SAIL/TISCO, and mini steel plants. The saleable steel sold during 1988 was 412,000 tonnes, and is expected to be 310,000 tonnes during 1989. The CSO sells coal, and other by-products. They help in purchasing raw materials from outside and also market Kulti and Ujjain's products. The sales is done either directly to the major customers or through the stock yards.

There will be a reduction in the sale of saleable steel as production will decrease at the Burnpur Works till modernization is completed. CSO will also undertake the purchases of construction steel for modernization -(500 varied sizes of 100,000 tonne lot size).

Restructuring of the marketing system may be carried out to accommodate the changes during modernization and after. The CSO may be made to report to the Central Marketing Organization of SAIL (as against the MD IISCO, at present). The CMO has 46 sales outlets all over the country and is a larger organization with bigger turnover. This may be formally done through an Act of Parliament which would merge the two organizations. Problems of suitability integrating the present marketing personnel of CSO - within the CMO/SAIL structure has stood in the way of such a merger.

PRODUCTION SYSTEM

Steel Making Process at Burnpur Works

The Steel Industry uses process technology. The inputs-raw materials such as coal, iron-ore, dolomite, lime stone are transformed into outputs which are either semi-finished like ingots or fully finished products like structurals, rails, etc.

Coal from the collieries is fed into the coke ovens and various gases arc removed from the coal. Heat is provided by the batteries and the metallurgical coke is removed. This is the first stage in the process. From raw coke oven gas, vital coal chemicals are recovered for manufacture of a number of by-products like Ammonium Sulphate, Benzol products and crude tar. Crude tar is used within the plant as a fuel for open hearth furnace. The clean coke oven gas is used as fuel for various units in the plant including coke over batteries.

The major inputs for the Blast Furnace include metallurgical coke, iron-ore, lime stone, dolomite, manganese ore, etc. Hot metal produced through smelting is either sent for steel-making or poured in pig casting machines for use at Kulti or Ujjain, or for sale to other customers. Slag produced in the process is supplied to cement manufacturers. The by-product blast furnace gas, serves as an important gaseous fuel for the plant,

The conversion of molten iron into steel is effected through the Duplex Process of steel-making, a combination of Acid Bessemer Converters and Basic Open Hearth Furnaces. In October 1988, the Bessemer Converter was removed from operation. The energy requirement is industry coke oven gas, furnace oil and crude tar.

Steel is conventionally steemed into ingots and supplied to the Blooming Mills where it is rolled into blooms and slabs. The Blooms and slabs are converted to Billets or sheet bar and fed to finishing mills. Some amount of Blooms/Billets are also sold to re-rollers.

A brief list of the major equipment in the Burnpur Steel Works is given below:

Table IV Brief Description of Main Plant

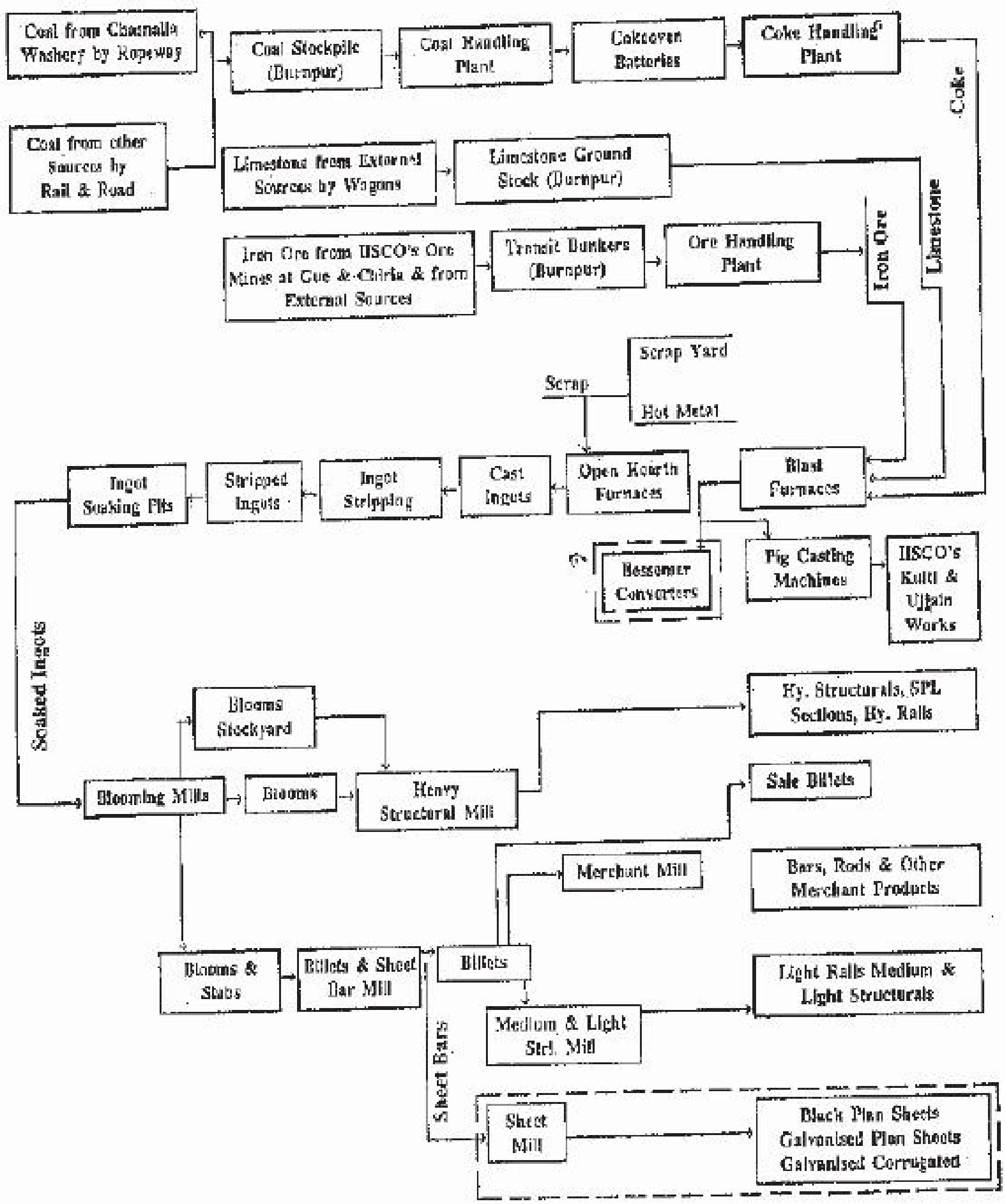
Department	*One Million Ingot Tonne Plant*				
Coke Ovens	4 batteries-306 ovens of 4.45 m height coal (dry) throughput 5,998 tonnes day				
By-product Plant	Tar, Naphtha, Benzol and Ammonium Sulphate units				
Blast furnace	Hearth dia	No. of fces.	Capacity per day	Working Vol (dbm)	
	(m)		(Tonnes)		Yearly capacity 1.3 million tonnes
	5.2	2	700	434	
	7.6	2	1200	1041	
Pig casting machine	2 numbers-600 tonnes/day each				
S.M. Shop			Capacity	Type	
	3 Bessemer convertors				Yearly capacity 1.0 million tonnes
	6.O.H. furnaces		225	Tilter	
	1.O.H. furnace		100	Fixed	
Lime shaft kiln	4 numbers-30 tonnes each				
Rotary dolomite kiln	1 number-100 tonnes/day				
Rolling Mills					
Soaking pits & Blooming mill	32 numbers-40 tonnes each "Sack" 2 Hi-Reversing 42" x 96" size of rolls				Yearly capacity 1.0 million tonnes
Sheet, Bar & Billet Mill	"Morgan"; No. of stands in Tandem-10				Yearly capacity 8,00,000 tonnes
34" Strl. Mill (HSM)	1 2-Hi Reversing roughing stand 1 2-Hi Reversing intermediate stand 1 2-Hi Reversing finishing stand				Yearly capacity 2,50,000 tonnes
18" Strl. Mill (LSM)	2 3-Hi Non-Reversing roughing stand 1 3-Hi Non-Reversing intermediate stand 1 2-Hi Non-Reversing finishing stand				Yearly capacity 1,20,000 tonnes
Sheet Mills	'Lewis' Two, 3-Hi roughing stands 'Hyde Park'-Four 2-Hi finishing stands				Yearly capacity 1,20,000 tonnes
Continuous merchant & Rod Mill	2-Hi Morgan-19 stand Edgers-4 Nos.				Yearly capacity 1,50,000 tonnes
Services					
Power Plant	60 MW Installed capacity				
Water Plant	Make up-2, 045 m^3/hr., including 170 m^3/hr. for drinking				
Township	23 million litres/day filtered, 9 million litres/day unfiltered				
Diesel electric locos	48 numbers-235/470/670/1100 H.P.				

Source: Statistics for Iron & Steel Industry in India, 1974, Ranchi.

Note: 1) One of the Coke Oven Bat (No. 7) phased out in June 1989 and another (No. 9) under rebuild from 1987.
2) One small B.F (No.1) phased out in April 1989.
3) Three Bessemer Convertors phased out in Oct. '88 and 100 tonnes stationary O.H. furnace phased out in private sector era itself.
4) Sheet mills has been phased out in June '89 and light structural mill will be phased out in near future.

The production Flow Chart, of the steel making process, presently is as under:

Table V Burnpur Works — Production Flow Chart



Note: Dotted lines indicate change in production flow with phasing out of units already completed.

Style

Style is what the top management of an organization dots (as opposed to what it says). It includes tangible evidence of what management considers important by the way it collectively spends time and attention and uses symbolic behaviour.

The Burnpur Works was initially manned by European managers. Their benevolent and patriarchical style saw a bustling township emerge with schools, a park and residential quarters for the officers.

The Management style of IISCO was personified by its Chairman Sir Biren Mukherjee, for nearly four decades. The obituary of Sir Biren, in the IISCO Newsletter 'Yours Faithfully' - (Dec. 1982 issue) described his style in the following words:

"An era came to a close with the passing away of Sir Biren Mukherjee, on November 4, 1982, It was an era of entrepreneurial leadership, result oriented approach and authoritarian management. Sir. Biren was more Often mentioned and referred to then seen or heard at Burnpur. His direct involvement with Indian Iron lasted for just a year short of your long decades but his association with the managing agents of the company was older by a near decade. He led IISCO to the pinnacle of its glory. He did not court the establishment, which cost him dearly."

Sir Biren Mukherjcc had the distinction of arranging the first private sector loan for any industry in India from the World Bank. This was a US $ 31.5 million loan in 1953, to cover the foreign exchange requirements of the expansion of the steel plant to 700,00 MT/Yr. This is perhaps. a measure of his stature in the country then.

There was a fedual streak in this style, which was revealed in the low housing level (below 17% in 1972) provided for the workers and staff. Only accommodaeion for officers was provided for fully, most of these officers being foreigners.

Due to rapid turnover of top executives since nationalization, no discernable personal style could be noticed. However, the advent of Mr. V. Krishnamurthy as Chairman-SAIL in 1985 has created a new style of management. Mr. Krishnamurthy is a "great helmsman" of the public sector. He has been credited with the successful establishment of the Bharat Heavy Electricals Limited (BHEL) and the Maruti Udyog Limited.

Business India (May 1-14, 1989) in an article headed "Reanimating a giant", credited Mr., Krishnamurthy with presiding over an organizational metamorphosis in SAIL. His stewardship was reported to have resulted in labour overtime cost being out down to, almost nothing from Rs. 40 crores earlier, inspite of having 240 unions to contend with. This was clone by taking the workers in confidence at every stage.

He had in his four }ears in SAIL, wiped out cumulative losses of Rs 300 crores and had initiated a capital spending programme of Rs 15,000 crores over seven years to double steel production and labour productivity ---(to be funded only by internal accruals). The Bumpur modernization was one part of this programme.

A distinct feature of Mr. Krishnamurthy's managerial style was the regular meetings he held with, shop floor managers, supervisors and trade union representatives, in all the steel plants. In one such meeting at Burnpur, held in November 1988, he emphasised that "What is required here is the determination to succeed...... you must learn to swim against the current... or get ,washed away".

The present Managing Director of IISCO Mr. M.F. Mchta has had the longest tenure since nationalization. (Six years so far). A veteran steel technologist, with more than thirty years of experience in the- steel industry, he moved to Burnpur from the Bokaro Steel unit of SAIL- Bokaro records for production of steel were set under his leadership,

Mr. Mchta spends most of his time on the Burnpur Works. He makes two/three trips a month to Kulti and five/ six trips/year to collieries and mines. The Ujjain unit is visited twice a year.

Shri, Mchta in an interview with the case-writers, explained his style of decision-making, "My day starts at 6 a.m. when I receive the previous day's production figures on the phone. Around 7 a.m. there is a tole-conference between various G.Ms from their homes - I tune into it at my residence. I visit the plant around 9 a,m, I don't believe in meetings (for decision-making). I meet people individually. I have allotted time to various functionaries throughout the day. Pending problems are solved on the spot during this period. The evening is devoted to paper work, No work is taken home."

Shri, Mehtst is scheduled for retirement from service in 1990.

SAIL has a poor record in project implementation (sec Table 8), The successful completion of the modernization programme at Burnpur (and in SAIL) appears to depend to a large extent on the quality of leadership and decision-making at IISCO and SAIL after Mr. Krishnamurthy/Mr. Mchta have retired.

Staff

Staff relates to human resources (i.e. the people in an organization) and its related dimensions - morale, attitude, motivation, and behaviour. Corporate demographic details rather than individual personalities are included in this variable

As on 1.6.89, all units of IISCO, together employees 37,210 employees comprising of 1,503 executives and 35,707 non executives

The break-up of non-executives in various units is as follows:

Bumper:	Works	16,387
	Admn: & Other	4,309
	Total	20,696
Kulti		5,691
Collieries		6,774
Mines		2,133
Calcutta &Branches		413
		35,707

There are about 3,000 contract workers. The present Industrial Relations culture was described thus by the Personnel Manager.

"There has been no problem for the last three years. Plant personnel are looking forward to modernization. Though we changed duty timings and stopped, overtime, there has been no protest. The workers have been told that the only alternative to modernization is shutting down the plant.

"We have five functional unions - INTUC, CITU, HMS, AITUC, BMS. Though INTUC is the recognized Union, negotiations have been undertaken with all the five unions. A common agreement is signed with all unions. We do not ascertain the actual numbers supporting each union, as this would be constructed as interference. Yes, the numbers given to the Labour Authorities (on Union strength) are fictious. There have been no strikes and lockouts since I have joined the plant. The State Government usually calls for a bandh three days in a year - special passes are issued to 3000 workers who are allowed to come inside. We have not retrenched anyone after the takeover in 1972."

The manpower strength at the time of takeover (in 1972) was 36, 604, of which 35, 740 were non-executives and 864 executives. After 1972 there was addition to the manpower and it reached the high of 43,597 in 1984. In the recent past manpower had been planned and brought down through a voluntary retirement scheme and by natural separation with not much addition to the employees strength. After modernization, the projected requirement of manpower according to the JICA report is 14,134 at Burnpur Works. The present strength of 20,696 non-executives has to be trimmed down. The new technology will call for new skills. The modernization apart from bringing about technological changes calls for changes in attitudes and skills of the employees, for which employees have to be retained. Around 1500 new recruits will be added to the existing workforce by 1995.

Voluntary Retirement Scheme

A voluntary retirement scheme which was implemented first by SAIL, was extended to II5CO in Oct. 1986, The retirement age which was 60 years at IISCO, was changed to 58 years for non-executives who joined after 06-01-79 and executives who joined after 01-06-73. The eligibility for the voluntary retirement are employees with 10 years of experience, and above 40 years of age those who retire at 58 years of age, and above 42 years for those retiring at 60 years. By March, 1989, 1,783 employees have gone on voluntary retirement. The distribution of voluntary retirement by year and status is given below:

Table VI Voluntary Retirement by Year & Status

Years	IISCO	Non-Executives	Executives
1986-87	325	319	6.
1987-88	940	916	24
1988-89	518	507	11
Total	1,783	1,742	41

A task group has been appointed to identify the eligible employees and to counsct them to take voluntary retirement. At Burnpur Works, in the next four years, 1837 non-executives and 156 executives who are in the age group of 56-60 will retire by 1993. The employees between 40-55 years of a age will be the target population to be counselled for voluntary retirement. The agewise distribution of employees is given in the table below:

Table VII Agewise Distribution of Employees

Age Group	Non-Executives	Executives
42-49	4,991	356
50-55	3,390	244
56-60	1,837	156

Redeployment

With impending changes, the concerns of staff related mainly to their status after modernization. "The letters from the Managing Director's desk", in the Newsletter tried to assuage these concerns. The Sept. 88 issue reads ... "While it had been repeatedly emphasised that permanent employees would not be retrenched and that on redeployment an employee's employments would be protected, it is essential that employees earnestly take up whatever work they are offered. A sizable portion of our employees would have to be redeployed, in various activities, of modernization and later absorbed in the new plants. Some of our employees would also have to be redeployed within the existing plant."

With the assurance that no retrenchment is to be carried out, redeployment has become a major issue.

Redeployment Plans: The excess manpower - the less skilled employees above 48 years of age are to be redeployed in other areas like projects, for the construction work and 46 kms. of tract laying work at the site. Employees will also be used for dismantling of the existing machinery which are being phased out. Redeployment will also be done in the areas where contract labour is presently being used. Presently there are 900 contract labourers in the coal handling area. Contract labour jobs are to be abolished in the future. Union agreement has been obtained on this issue.

The present manpower distribution in the major areas is as under:

Table VIII Manpower Distribution in Major Areas of Burnpur Works (as on 1.6.1989)

Area	Non-Executives	Area	Executives
Coke Oven	1530		
Blast Furnace	1124	Operation	222
Steel Melting Shop	981	Maintenance	284
Rolling Mills	2015	Service	127
Sheet Mills	1357		
Maintenance & Service	8023		
Total of 13umpur Works	16387	Total of 13urnpur Works	633

The manpower requirement after modernization (as per JICA report) is given in the following table:

Table IX: Manpower Requirement after Modernization

	Division	Manpower Estimates Numbers Required Presently	(figures in brackets show requirement after step 2)
1.	Personnel and Labour Relations	305	
2.	Finance & Accounts	82	
3.	Administration	133	
4.	Purchase	50	
5	Technical Control	237	
6.	Production Control	349	
7.	Iron Making	1,326	(1,605).
8.	Steel Making	561	(777)
9.	Rolling	2,953	(2,390)
10.	Equipment Maintenance	4,725	(5,224)
11.	Energy	391	
12.	Transport	4,569	(4,201)
13.	Laboistories	189	
14.	Engineering centre	121	
	Total	15,991	(14,134)

Productivity: First Step: 62 MT/Man Year.
Second Step: 152 MT/Man Year.

The redeployment exercise has to be carried out in a manner that the future requirement is met from the present manpower - who need to be suitably trained for their new jobs.

Skills

Skills are those dominating attributes or capabilities which demonstrate what the organization does best. Skills are those capabilities that are possessed by an organization as a whole as opposed to the people in it. It could be viewed as a derivative of the other 'S's'.

At the Burnpur Works' skills in the pre-nationalization days were in the area of project implementation and production. For instance, the `History of IISCO' claims that "the iron-making plant in the 1920s was upto date than any average European plant and the management was as efficient as in Europe". (page No.44).

The erection of the steel plant and its three expansions were all done within the scheduled time-limit and within the stipulated costs. The last expansion (in 1955) was completed 13 months ahead of schedule and saved foreign exchange due to import substitution. One of the Works' Indian managers received the prestigious Carnegi Silver medal in 1958, from the Iron & Steel Institute, London, for his contributions to steel-making process.

The post-nationalization era saw a distinct dilution in technical skill which was held as one of the causes for poor production performance. However, some of the Works' shop floor managers claimed that operating and maintaining the vintage machinery was itself a technical feat

The productivity of the Blast furnaces (two of which were established in the 1920s and two in the '50s) was said to compare favourably with those of even Bhilai or Rourkela (which had more modern machinery) in spite of poor raw material quality.

Marketing is another function where corporate skill is evident. An IMRB customer satisfaction survey ranked IISCO along with TISCO and ahead of CMO of Sail. The Chairman of SAIL and IISCO, Mr. V. Krishnamurthy has publicly praised the marketing department's performance - IISCO's CSO has sold products of other plants of SAIL at 2.5% commission, when CMO could not deliver the service, A crucial skill in the furnace will be ability of the Burnpur Works to complete the project within stipulated cost and time limits. SAIL's records in this area is poor. (See table below).

Table X Sail's Sad Legacy: Project Cost & Time Overruns
(from Business World March 1-14 issue, pg. 50)

Project	Capacity	Month of Govt. approval: Original/ (revised)	Approved cost (Rs. in Crores)	Final Cost (Rs. in Crores)	Costover-run (Rs. In Crores)	Time over-run (months)
Alloy Steel plant Expansion	100,000 tpa	July '81	66	113	47	32
Bhilai		Mar. '76	938	2,262	1,324	73
expansion	1.19 m tpa	(Dec. '86)	(2,263) *			
Bokaro	1,17 m tpa	Mar. '73	947	2,072	1,125	131
expansion		(Dec. '82)	(1,638) *			
Captive power	3 x 60 MW	Sept. '78	76	145	69	51
plant, Bokaro		(Dec. '82)	(128) *			
Captive power plant,	2 x 60 MW	Sept, '78	55	125	70	54
Durgapur		(Oct. '81)	(82)			
Captive power plant,	2 x 60 MW	Jan. '81	80	210	130	30
Rourkela						

* Revised cost estimates (figures rounded to the nearest crore)

Source: Ministry of Programme Implementation Report, 1987-88

Retraining

The new technology to be adopted after modernization required new skills for operation. The learning of these new skills will entail attitudinal change- the plant, after modernization will be operating at four time the present production level with two-thirds of the manpower. For example the testing time in the laboratory which is presently 48 hours has to be cut down to eight hours.

A comprehensive two-year training programme has been drawn up, As phasing Out operations start, at least 50 per cent of the employees below 48 years of age, are planned to be withdrawn for training. The withdrawal of workers for training is being planned for synchronization with the phasing out of units. The training of employees for the future technology will be in the respective areas of work. The training wilt be given on the job in other steel plants where such technology is already available. The following table gives the summarised training plan.

Table XI: Training Plan in Man Days

	Field		Training given by Indian Trainer's in India	Training given by Trainers despatched by Eqpt. & Tech. giving Eqpt. & Tech. Manufacturers at Burnpur	Training given by countries giving Eqpt. & Tech.
1	Sintering -	Ore Yard	0	1,037	122
		- Sintering	0	1,403	122
2	Blast Furnace	- X	0	1 500	1 056
3	Basic Oxygen Furnace:	- B.O.F	750	1,600	750
		Line calcining	110	0	110
4.	Continuous Casting:	-Blooms CC	378	158	189
		Billets CC	378	158	189
		Rolling Bar	0	530	1 050
5.	Maintenance:		0	30	0
		- Machine			
		- Forging	0	50	0
		- Central	0	1.650	3.256
		- Local	0	1 650	3 960
6	.Power:				
		- Receiving &Distribution	0	0	120
		- Oxygen	480	120	0
		- Blast Furnace	0	120	240
		- Gas	0	120	240
		Grand Total:	2,096	10,126	1,404

Case Closing

The Burnpur Steel Works had been regarded as a model steel making unit, perhaps in Asia for much of its existence. The last twenty years had seen its performance and reputation dramatically slide-downwards. A stage had been reached, where the possibility of the Works being shut down was being considered as a possible strategic alternative. The Managing Director, Mr. M.F. Mehra realised that the Burnpur modernization was a complex task. The "infusion of technology" solution could not alone suffice. Mr. Mchta was also acutely aware, that the restructuring decisions that had to be taken, could either rebuild the works as a model steel plant, or push it towards the path of getting wiped out of existence.

Questions

i) What are the main features of technology modernisation programme of IISCO?

ii) Present pictorially the restructuring of the organisation using McKensey's 7-S Framework.

iii) What is the financial cost of modernisation? In what ways could the company raise the necessary funds?

iv) What personnel and industrial relations problems you envisage for the company in undertaking the modernisation programme? How could such problems be prevented?

v) What are the critical interfaces that must be managed in the introduction of new technology so that the project is compared in time and within the budget and also that the full capacity is utilised.

Exhibit I
Chronology of Major Events

	1870	-	Bengal Iron Works formed
	1872	-	Commencement of Iron Production
	1880-81	-	Govt. takes over Bengal Iron Works
	1890	-	Formation of Bengal Iron & Steel Company
	1892	-	Martin & Co. appointed as managing agents
	1916	-	Iron ore mining starts at China
11 March	1918	-	Indian Iron & Steel Company established
	1919	-	Iron ore mining starts at Gua
.	1920	-	Iron ore mining starts at Ramnagore
2 Dec.	1936	-	IISCO absorbs Bengal Iron
20 April	1937	-	Steel Corporation of Bengal (SCOB) formed
June/July	1938	-	Labour strike & Lockout for 28 days at Kulti
	1939	-	First heat of steel tapped
	1944	-	Asansol Iron & Steel Workers Union formed
31 Dec.	1952	-	Govt. Ordinance merging IISCO& SCOB
December	1953	-	First World Bank Loan negotiated
	1955	-	United Iron & Steel Workers Union formed
30 April	1956	-	Industry Policy resolution of ruling party
December	1956	-	Second World Bank loan negotiated
13 May	1958	-	Mechanised iron ore mining at Gua
	1959	-	Burnpur township inaugurated
December	1961	-	Third World Bank loan negotiated
	1963-64	-	Record production of steel
	1967	-	Asansol, Burnpur, Kulti Metal & Engineering Workers Union formed
			Burnpur Iron & Steel Workers Union formed
	1969	-	Burnpur Ispat Karmachari Sangh formed
14 July	1972.	-	IISCO taken over by Government
4 Sept.	1972	-	Indian Iron & Steel Act passed
	1973	-	Submission of plant rehabilitation scheme
December	1975	-	Chasnalla mine disaster
July	1976	-	Acquisition of shares by Government
30 April	1978	-	IISCO made a subsidiary of SAIL
	1983	-	Russian feasibility report on modernization
June	1987	-	Japanese (JICA) feasibility report
November	1988	-	Agreement with Japanese Consultants (JCC) on preparation of Basic Engineering Report (BER)
June	1989	-	Submission of draft BER by JCC

Exhibit I(A)
Commissioning Date of Plant and Equipment

Equipment	Date of Commission	Remarks
Coke Oven		
No. 1 Battery	1922	Shut down in 1950
No. 2 Battery	1922	Shut down in 1950
No. 3 Battery	1922	Shut down in 1948
No. 4 Battery	1922	Shut down in 1948
No. 5 Battery	1929	Shut down in 1977
No. 6a Battery (30 ovens)	1939	Shut down in 1977
No. 6b Battery (10 ovens)	1947	Shut down in 1977
No. 7 Battery	1950	Phased out by June '89
No. 8 Battery	1957	Rebuilt in 1987
No. 9 Battery	1958	Shut down for rebuilding from 1987
No. 10 Battery	1982	
Blast Furnace		
No. 1	1922	Phased out by April '89
No. 2	1924	
No. 3	1958	
No. 4	1958	
Steel Melting Shop		
Bessemer Plant	1946	Phased out in Oct. 1988
Open Hearth Furnace		
A	1939	Refitted with Air injection tech.
B	1940	Converted to KORF process July '89
C	1940	Converted to KORF process Nov. '88
D	1942	Phased out before 1972
E	1958	Converted to KORF process July '88
F	1959	Equipped with Air Injection
G	1959	Technology
Rolling Mills		
Blooming Mills	1939	
Billet and Sheet bar Mill	1953	
Heavy Structural Mill	1939	
Light Structural Mill	1939	
Merchant Mill	1960	
Sheet Mills	1939	Phased out [illegible] '89

Exhibit II
List of Chief Executives—IISCO

1928-36 Sir Rajen Mukherjee (Chairman)
1936-72 Sir Biren Mukherjee (Chairman)

POST-TAKEOVER

July 1972 – Nov. '72	Shri M.P. Wadhawan (Part-time Custodian)
Nov. 1972 – Nov. '74	Shri Arobinda Ray (Custodian)
Nov. 1974 – Dec. '75	Shri Hiten Bhaya (Chairman)
Dec. 1975 – June '78	Shri V.K. Dar (Administrator/Managing Director)
June 1978 – Mar. '81	Shri D.R. Ahuja (Managing Director)
Mar. 1981 – Nov. '81	Shri S. Samarapungavan (")
Jan. 1982 – June. '83	Shri K.R. Sangameshwaran (")
July, 1983 onwards	Shri M.F. Mehta (")

BURNPUR STEEL WORKS—LIST OF OPERATIONAL CHIEFS

May 1961 – Apr. '71	Shri J. McCraben (Chief General Manager)
Apr. 1969 – Sept. '72	Shri F.W. Lahmeyer (General Manager)

AFTER TAKEOVER

July 1972 – Dec. '73	Shri N.R. Dutt (Chief General Manager)
Jan. 1973 – Jan. '75	Shri A. Bajekal (General Manager)
Dec. 1974 – Sept. '77	Shri S. Chatterjee (General Manager)
Sept. 1977 – Sept. '78	Shri P.R. Mehr (General Manager)
Sept. 1978 – Feb. '80	Shri P.K. Rath (General Superintendent)
Feb. 1980 – Oct. '81	Shri S.K. Roy (General Superintendent)
Oct. 1981 – Jan. '82	Shri K.R. Sangameshwaran [General Manager (Works)]
Feb. 1982 – Aug '83	Shri B.B. Dutta [General Manager (works)]
Aug. 1983 – Nov. '84	Shri C.R. Srinivasan [GM (works)]
Nov. 1984 – May. '87	Shri K.D.S. Dhillon [GM (works)]
June 1987 onwards	Shri M.S. Chawla [General Manager (works)]

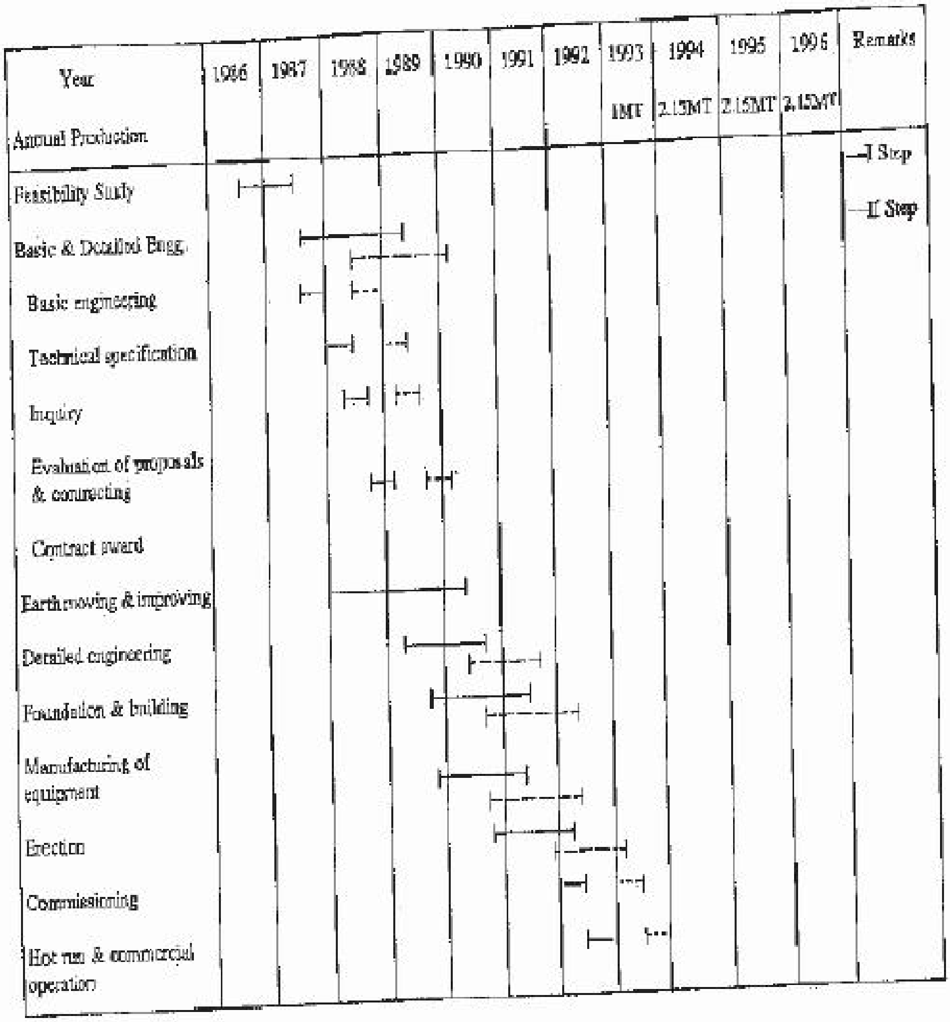
Exhibit III
Changes in Burnpur Steel Plant after Modernisation

	Present Condition Nominal Capacity 1 Million MT/yr 85/88 Output 565,000 MT	1st Phase Completed in end 1992 1 Million MT/yr	2nd Phase Completed in end 1993 2.15 MT/yr (AS PER JIGA REPORT)
Coke Ovens	4 coke oven batteries, No. 7/8/9 &10, 127 out of 228 ovens operated.	Nos. 8,9 &10 batteries operational	Nos. 8 & 9 operational 92 oven batteries installed (no. 11)
Sinter Plant	None	No. 1 sintering Machine (210 sq. metres) installed	No. 2 sintering machine (210 sq. met.) installed.
Blast Furnaces	500 m3 BF x 2 1170 m3 BF x 2	All four BFs shut down. No. 5 BF (2250 m3) installed	No. 6 BF installed (2250 m3) Two BFs operational
Steel Melting Shop	Duplex process Bessemer (25T x 2) Open Hearth (225T x 6)	Two BOFs (130T) intalled. Of these two one unit will continually operate. One lime calcinating plant installed	One BOF (130T) installed. Of 3 units, 2 will continually operate. One more lime calcinating plant installed.
Continuous Casting (CC) Plant	None	Bloom (BL-1) CC 3 strand, 300 mm x 400mm. installed Billet (BT-1) CC 3 strand type installed	Two more Billet CC (BT-2, BT-3) installed. (8 strand type 150mm x 180mm)
Rolling Mills	Blooming Mill, Billet & Sheet bar Mill, Heavy Structural Mill, Light Structural Mill, Merchant & Bar Mill, Sheet Mill, Galvanising Line.	Light Structural Mill shut down. All other mills remodelled and used. New bar and section Mill installed. Capacity 600,000 MT/year.	Sheet Mill shut down. 2nd Bar & Section Mill installed. Capacity 70,000 MT/year
Captive/power Plant	60 MW capacity (achievable capacity 25 MW)	One 60 MW unit.	One more 60 MW unit installed. Old unit shut down
Site Area	2.6 square metres (existing plant)	Site available for new units: 1.5 to 1.8 square metres.	
Personnel	20,696	15,991	14,134
Productivity	20-30MT Manyear	62MT/Manyear	152MT/Manyear
Investment		Rs. 1292 crores	Rs. 1157 crores

Note: With the phasing out of units there were more ongoing changes in the 'PRESENT CONDITION'. These were:

- Of the four coke oven batteries, only two were in operation. Of the remaining two, one had been phased out, and another was being rebuilt.
- Only three blast furnaces were in operation. One small blast furnace had been phased out.
- At the steel melting shop, duplex process of steel making were being discarded with the phasing out of the Bessemer Convertors. Only "KORF" process and "AIR INJECTION" processes were used in Open Hearth furnaces for steel making. Of the six OH furnaces, normally three in operation.
- Sheet mills had been phased out.

Exhibit IV
Schedule of Modernization



Basic construction schedule

CAPITAL REPAIR SCHEDULES

UNIT	3 YEAR ROLLING PLAN 1989-90	1990-91	1991-92
COKE OVENS: No. 9 Battery	— Under rebuild	— Ready for Commissioning after rebuild	— Ready for Commissioning after rebuild
No. 10 Battery	Recovery of 4 Ovens in the 1st Qr (completed)	—	—
BLAST FURNACE: No. 3 P.C.M.	15 days-Apr. '89	15 days-Apr./ May, '90	15 days-Apr./ May, '91
No. 4 P.C.M.	15 days-May/ June, '89	15 days-May/ June, '90	15 days-May/ June, '91
ROLLING MILLS: Blooming & Billet Mills	12 days-Sept./ Oct. '89	18 days-May/ June, '90	12 days-Apr./ May, '91
H.S. Mill	8 days-June '89 (taken down from 30th June)	10 days-July '90	8 days-July '91
M&R Mill	12 days-May '89 (deferred)	12 days-Apr. '90	Under
BOILERS:			
No. 10	40 days-Apr./May 89	Boiler overhauling schedule will be determined at the beginning of each financial year.	Same as 1990-91
'A'	40 days-May/June '89		
No. 7	40 days-July/Aug. '89		
No. 1	35 days-Aug./Sept. '89		
No. 2	35 days-Sept./Oct. '89		
No. 6	35 days-Oct./Nov. '89		
No. 11	40 days-Nov./Jan. '90		
No. 8	40 days-Jan./Feb. '90		
No. 4	35 days-Feb./Mar. '90		

Payment by Year of Investment and Source of Fund

(Total) (Unit: Rs. in lakhs)

Items	1987	1988	1989	1990	1991	1992	1993	Total
Land	0	2,008	2,008	1,721	0	I 38 0	0	I 38 5,737
Building	0	0	1,151	4,578	6,287	I 1,812 2,779	532	I 1,812 15,327
Machinery & equipment	0	0	13,033	31,476	71,043	I 6,003 62,597	14,612	I 6,003 192,961
Vehicle	0	0	0	54	483	I 735 2,623	2,727	I 735 5,887
Spares	0	0	0	0	0	3,087	2,156	5,243
Engineering fee	771	1,325	1,183	1,183	1,183	1,183	568	7,396
Training	0	0	0	0	10	252	38	300
Technical assistance	0	0	0	0	0	391	80	471
Pre-operating expenses	37	69	59	59	59	59	28	378
Sub-total	800	3,402	17,434	39,071	79,865	I 8,588 72,971	20,941	I 8,588 233,692
Interest during construction	16	58	267	833	2,193	4,773	3,034	11,174
Total	624	3,460	17,701	39,984	81,258	I 8,588 77,744	23,974	I 8,588 244,866
a & b Domestic portion	268	2,475	11,262	26,122	50,380	I 8,588 49,408	16,137	I 8,588 156,852
c Imported portion	556	985	6,439	13,782	38,878	28,336	7,838	88,814
(Source of fund) a. Capital	268	2,475	11,262	26,122	47,640	I 8,588 29,079	0	I 8,588 116,846
b. SDF Loan	0	0	0	0	2,740	20,329	16,137	39,206
c. EXIM loan	556	985	6,439	13,782	38,878	28,336	7,838	88,814

Notes: 1) I Book value of existing facilities

2) Amount by item is acquisition cost of fixed assets, etc.

Exhibit V
Production Phasing Programme

ITEM	Unit	3 YEAR ROLLING PLAN 1989-90	1990-91	1991-92
PRODUCT-MIX:				
Semis	('000 T)	41.3	41.3	177.5 Blooms 32.0 Billets 145.5
Bars & Rods	"	104.0	104.0	
Structurals	"	141.0	141.0	101.0
Special Sections	"	19.0	19.0	19.0
Total:	"	305.3	305.3	297.5
MILL-WISE SALEABLE STEEL:				
Blooming Mill	"	33.6	33.6	32.0
Billet Mill	"	7.7	7.7	145.5
H.S. Mill	"	120.0	120.0	120.0
M & R Mill	"	144.0	144.0	—
Total Saleable Steel:	"	305.3	305.3	297.5

Equipment Availability/Utilisation/Productivity

ITEMS	Unit	3 YEAR ROLLING PLAN 1989-90	1990-91	1991-92
A. COKE OVENS				
Availability	%	66.7	66.7	66.7
Utilization	%	97.5	97.5	97.5
Productivity	T/utilised hr.	43.0	43.0	43.0
B. BLAST FURNACE				
Availability	%	100.0	100.0	100.0
Utilization	%	98.4	98.4	98.4
Productivity	T/m³ of useful vol./day	0.80	0.80	0.80
C. STEEL MELTING SHOP				
Availability	%	50.0	50.0	50.0
Utilization:				
'KORF'	%	80.0	80.0	80.0
AIR INJ.	%	85.0	85.0	85.0
Productivity:				
'KORF'	T/utilized Fee. hr.	22.9	22.9	22.9
'AIR INJ.'	"	14.3	14.3	14.3
D. BLOOMING MILL:				
Availability	%	94.0	92.3	94.0
Utilization	%	32.8	32.8	31.1
Productivity	T/Hr.	130.0	130.0	130.0

Exhibit VI(a)

ORGANISATION STRUCTURE OF INDIAN IRON AND STEEL COMPANY LTD.

as on April 1989

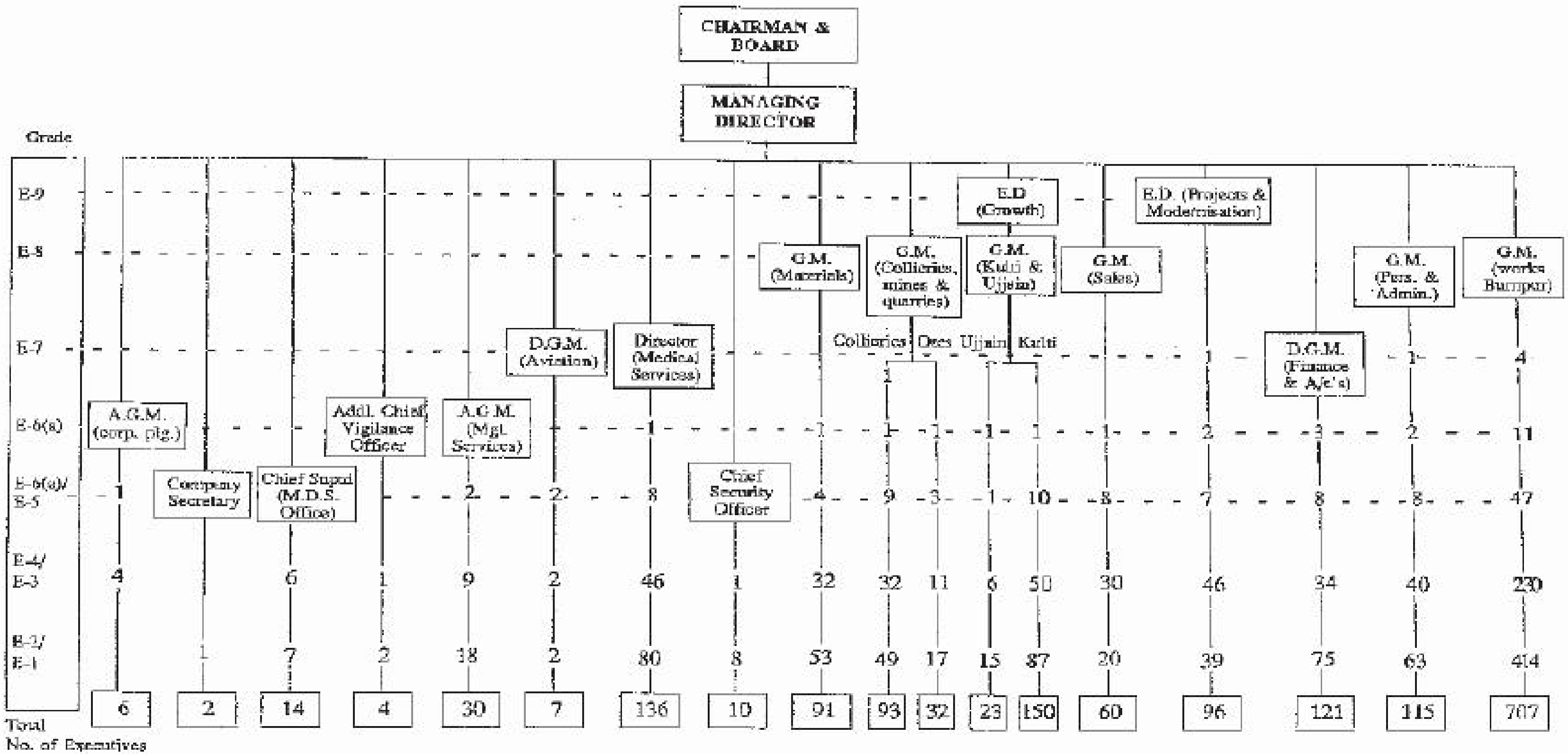


Exhibit VII

Daily Profitability Statement as on 8th March 1989 for Steel Melting Shop

BUDGETED Rate/Unit	Quantity To Date	Value(Rs/Lac) To Date	Description	Unit	ACTUAL Rate/Unit To Date	Quantity To Date	Value (Rs/Lac) To Date	Variance To Date
			(A) INCOME					
3598	7677.39	275.59	STEEL INGOT	M.T.	3590	5782.00	207.54	68.83
2368	230.30	5.39	SCRAP	M.T.	2360	173.46	4.06	– 1.33
1446	149.24	2.10	STEEL SKULL	M.T.	1446	112.42	1.59	– 2.51
			TOTAL INCOME					
			(B) EXPENDITURE					
			INPUT MATERIAL					
2628	8713.39	228.27	HOT METAL	M.T.	2620	7393.00	198.90	29.37
2268	1351.21	30.52	TOTAL SCRAP CHARGED	M.T.	2260	1215.00	27.42	3.48
7542	86.03	6.44	FERRO MANGANESE	M.T.	7542	72.46	5.28	1.16
5746	15.33	2.38	FERRO SILICON	M.T.	15746	11.73	1.83	8.57
882	575.75	5.04	BURNT LIME	M.T.	882	433.65	3.80	1.24
1489	214.90	3.01	BURNT DOLOMITE	M.T.	1409	161.86	2.25	8.76
6500	191.87	12.46	IMBP CONSUMPTION	M.T.	6500	138.99	9.01	3.45
			TOTAL					
			SERVICES					
1201	122.78	1.47	ELECTRICITY	M.T.	1201	92.48	1.08	8.39
169	2080.54	3.50	STEAM	M.T.	169	1566.89	2.61	0.89
315	9980.60	31.43	TOTAL FUELS	M.CAL	315	10557.24	33.22	–1.79
0	0.00	88.90	FIXED OVERHEAD EXPENSE		0	0.00	88.90	8.00
			TOTAL EXPENDITURE					
		–130.34	(C) PROFIT (+)/LOSS(–)				–161.09	–30.75

REASONS FOR VARIATIONS	TO DATE
VOLUME	1.93
TECHNO FACTORS	–32.68

COST DATA

ITEMS	BUDGET	TO DATE
COST OF PRODUCTION OF		
STEEL INGOT (RS/T)	5382.16	6177.60
COST VARIANCE (RS/T)		–795.44
DETAILS		
VOLUME		–380.82
TECHNO ECONOMIC		–685.72
ADL. FOR TRANSFER PRICE		270.30

Exhibit VIII

The Indian Iron & Steel Co. Ltd.
Comparative Working Results

(Rs. in lakhs)

	1983-84		1984-85		1985-86		1986-87	1987-88	1988-89
	Amount	%	Amount	%	Amount	%	Amount	Amount	(Provl.)
A. Earnings									
Net Sales	27946	83.89	27534	89.72	37156	99.00	48130	44381	46167
Other Revenue/adjustements	5748	17.23	3883	12.39	892	2.38	2250	–1376	411
Stock Accretion (+)/Decretion (–)	–372	–1.12	–649	–2.11	–517	–1.38	–262	1125	–2818
Net Income	33314	100.00	38688	100.00	37531	102.00	41918	44130	44568
B. Expenses									
Raw Materials	17274	51.85	17126	55.81	23104	61.56	26447	277762	26919
Stores & Spares	5673	17.03	5092	16.59	5961	15.88	6362	7986	8633
Employees' Remuneration & Benefits	9441	28.34	18651	34.71	10881	28.78	11336	12408	13699
Power & Fuel	3028	9.09	3915	12.76	4909	13.00	5299	5453	4291
Repair & Maintenance	3363	10.09	2705	8.81	2345	6.25	3141	3215	4017
Other Expenses	3413	10.25	2769	9.02	3125	8.33	3629	5050	3562
Interest	3189	9.57	3581	11.67	1191	3.17	1127	1088	731
Depreciation	1738	5.22	1728	5.63	1311	3.49	1407	1706	1675
Gross Expenses	47119	141.44	47567	155.00	52747	148.54	58748	64588	63747
Less: Inter A/c adjustment	11399	34.22	8717	28.41	9117	24.29	6639	8883	7794
Net expenses	35720	107.22	38848	126.59	436.30	116.25	52127	55785	55953
Profit (+)/Loss (–)	–2406	–7.22	–8168	–26.59	–6099	–16.25	–8191	–11575	–11365

Notes:
1) other income includes (a) Provision no longer required written back (b) adjustment pertaining to earlier year (c) interest earned etc.
2) Percentages have been calculated on earnings.
3) Raw materials includes purchase of semi-finished steel.

The Indian Iron & Steel Co. Ltd.
Summarised Balance Sheet

(Rs. in lakhs)

	As at 31.3.84	As at 31.3.85	As at 31.3.86	As at 31.3.87	As at 31.3.88
A. Funds Employed					
1. Share Capital	9345	10269	26016	27376	30976
2. Reserve and Surplus	210	192	205	209	358
3. Loan funds	28728	36945	28680	32546	37001
4. Bank Overdraft	5474	4705	3363	4182	3976
Total	43757	52131	58264	64313	72311
B. Application of funds					
1. Fixed Assets (Net)	15708	16038	18095	21933	25145
2. Investments	331	331	331	316	315
3. Current Assets	31425	32511	36043	33792	31882
4. Less: Current Liabilities	29149	30330	35885	39624	44960
5. Net Current Assets.	2276	2181	158	(5832)	(13078)
6. Misc. Expenditure	—	—	—	25	483
7. Profit & Loss Account	25442	33581	39688	47871	59446
Total	43757	52131	58264	64313	72311

The Indian Iron & Steel Co. Ltd.
Statement of Working Capital

(Rs. in lakhs)

	83-84	84-85	85-86	86-87	87-88
Current Assets					
A. Inventories					
1. Stores & Spares	6504	6594	6800	8275	8117
2. Finished Goods	4460	3948	3445	3174	3884
3. Goods in Process	615	478	464	465	904
4. Raw Materials	2553	2905	3278	036	2733
5. Loose Tools	—	—	—	—	—
Total	14132	13925	14867	14950	15638
B. Sundry Debtors					
1. Debts outstanding over six months	2725	3355	4854	3126	2935
2. Other Debts	4330	3504	4662	4075	4335
Total	7055	6859	9516	7221	7778
C. Cash & Bank Balance	1904	2688	1153	1030	1563
D. Loan & Advances	8324	9030	11298	10509	6905
E. Others (including Security Deposit)	10	9	9	82	6
F. Grand Total	31425	32511	36043	33792	31882
Current Liabilities					
G. Sundry Creditors					
1. For Goods	16058	20267	24927	29073	36562
2. For Expenses	2593	3870	3479	3220	2717
3. For other liabilities	6661	2426	3496	3562	2431
Total	25312	26563	31902	35855	41710
H. Advance Payments	2916	3037	3403	3170	2802
I. Other Liabilities	660	395	457	437	324
J. Interest on Overdraft & PRS Loan	261	335	123	162	124
K. Grand Total	29149	30330	35885	39624	44960
L. Working Capital	2276	2181	158	(5832)	(13078)

The Indian Iron & Steel Co. Ltd.
(Burnpur Works)
Earnings of Employees

	Unit	83-84	84-85	85-86	86-87	87-88
Salary & Wages	Rs./lacs	4965	6864	6454	6339	7441
Number of employees	Number	25104	24791	24323	23528	22735
Average earning per employee per month	Rs.	1643	2039	2210	2245	2727
Labour cost per tonne of Ingot	Rs.	914	1365	1142	1201	1364
Labour cost per tonne of saleable steel	Rs.	1119	1591	1290	1206	1373

Note: Figures relate to Burnpur Works only.

The Indian Iron & Steel Co. Ltd.
Cost of Raw Materials Purchased

	1979-80			1983-84			1984-85			1985-86		
	Basic Rate including levies & Taxes	Freight	Total	Basic Rate including levies & Taxes	Freight	Total	Basic Rate including levies & Taxes	Freight	Total	Basic Rate including levies & Taxes	Freight	Total
Coking Coal												
Washed	258	13	171	418	32	450	486	31	517	600	40	648
Unwashed	141	16	157	251	30	281	389	31	420	477	34	511
Chasnalla (Own)	252	16	268	463	16	479	466	16	482	524	37	561
Iron Ore												
Gua	47	29	76	73	68	135	67	60	127	64	60	124
Manoharpur	70	29	99	183	59	162	114	59	173	121	57	178
Purchased	42	38	72	61	62	123	75	64	139	06	62	148
Limestone												
B.F. Gr.	58	37	95	88	75	163	90	79	169	118	75	193
S.M.S. Gr.	43	78	121	43	160	208	59	160	219	71	180	251
Dolomite												
B.F. Gr.	59	37	96	101	75	176	106	79	185	110	75	185
S.M.S. Gr.	58	37	95	91	75	166	106	75	181	114	75	189
Ferro-manganese	3020	130	3150	6021	201	6222	6432	205	6637	7072	225	7297
Ferro Silicon	6218	245	6463	8385	620	9005	10668	460	10528	11965	672	12637
Aluminium	16035	—	16035	19925	—	19925	24817	—	24817	24226	90	24316
Zinc Spelter	13098	238	13336	24319	90	24409	27267	90	27357	26566	90	26655
Boiler Coal	110	13	123	234	29	263	292	28	320	304	30	334
Furnace Oil	1135	52	1187	2592	153	2745	2578	155	2733	2961	282	3243

(Rupees in lakhs)

RAW MATERIALS CONSUMED:
1987-88: (IISCO ALL UNITS)
(INCLUDING ORE & COAL FROM CAPTIVE MINES)

	Quantity Tonnes	1987-88 Value
Iron Ore	1224368	1822.48
	(1301208)	(1822.44)
Coking Coal	1544472	9963.54
	(1353628)	(8410.31)
Limestone	378836	877.68
	(374218)	(759.63)
Dolomite	228318	507.46
	(195187)	(382.20)
Manganese	28128	68.13
	(38841)	(94.31)
Coke	288604	4277.08
	(311874)	(4804.56)
Ferro Manganese	6283	487.36
	(5698)	(432.09)
Ferro Silicon	2311	323.54
	(913)	(113.79)
Spelter	2289	733.88
	(2630)	(758.58)
Sulphur	2202	50.46
	(2222)	(61.88)
Pig Iron	107578	3069.58
	(101711)	(2792.28)
Others	—	327.49
	(—)	(252.69)
Purchased Steel Ingots	12020	346.02
	(26389)	(795.91)
Purchased Steel Plates	8960	546.16
	(—)	(—)
Purchased Billets	12430	509.16
	(2104)	(69.87)
Imported Billets	49739	2594.90
	(46597)	(2493.43)
Purchased C.R. Sheets	8692	761.61
	(18912)	(1546.67)
		27328.23
		25592.64

Notes: 1) The shortage and excess of Raw Materials amounting to Rs. 316.92 lakhs (Rs. 512.27 lakhs) and Rs. 219.16 lakhs (Rs. 537.64 lakhs) respectively have been charged to consumption of Raw Materials.
2) Figures in brackets are for previous financial year.

Table VIII (G)
Financial Analysis of Tata Iron & Steel Co. Ltd. (TISCO)

INDICATORS	(Rs. in Crores) 1988	1987
Net Fixed Assets	861.88	708.09
Current Assets	917.54	820.98
Capital	136.01	82.63
Reserves & Surplus	476.33	401.05
Term Loans	495.50	422.19
Current Liabilities	700.66	634.21
Sales	1501.45	1392.82
Depreciation	73.98	57.60
Provision for Taxation	20.00	12.00
Net Profit	76.67	87.52
Dividend %age	25	25
FINANCIAL RATIOS:		
Rent Ratio	1.31	1.29
Net Worth/Total Assets (%age)	34	31
Return on Capital Employed (%age)	12.11	15.05
Net Sales/Total Assets	0.83	0.90
Receivables to Sales (days)	39	36

Total paid up equity of the company was Rs. 156.34 crores (Value per share being Rs. 100).
Source: Kothari's Industrial Directory of India 1990 Edition page 8-362.

Exhibit IX
Capacity Utilization of Steel Plants of SAIL (Crude/Ingot Steel)

(in Million MT)

Plant	Installed Capacity	Achievable Capacity	Target for 1989-90	% of installed Capacity	% of Achievable Capacity
IISCO, Burnpur	1.0	0.373	0.373	37.3	100.6
Durgapur	1.6	1,150	1,000	62.5	87.0
Rourkela	1.8	1,400	1,240	68.9	83.6
Bokaro	4.0	4,000	3,300	82.5	82.5
Bhilai	4.0	4,000	3,400	85.0	85.0
	12.4	10,923	9,131	75.0	85.6

Note: 1. The sole private sector Steel Plant at Jamshedpur (TISCO) has an installed capacity of 2.4 Million MT. It has consistently worked at 100% capacity.

Exhibit X
World's Top 25 Steel Producing Countries in 1987 and 1988

Country	(Million Tonnes) 1988	1987
1. USSR	164.0	161.9
2. Japan	105.7	98.5
3. USA	90.8	80.9
4. China	59.0	56.0
5. FR of Germany	41.0	36.2
6. Brazil	24.6	22.2
7. Italy	23.7	22.8
8. Republic of Korea	19.1	16.8
9. UK	19.0	17.4
10. France	19.0	17.7
11. Poland	17.0	17.1
12. Czechoslovakia	15.4	15.4
13. Canada	15.2	14.7
14. Romania	15.0	15.0
15. India	14.2	13.1
16. Spain	11.7	11.8
17. Belgium	11.2	9.8
18. South Africa	8.8	8.7
19. Taiwan	8.5	5.8
20. German Democratic Republic	8.3	8.2
21. Turkey	8.0	7.0
22. Mexico	7.8	7.6
23. DPR Korea	6.8	6.7
24. Australia	6.3	6.1
25. Netherlands	5.5	5.1

Source: IIS I

CURRENT STEEL PRODUCTION AND CONSUMPTION IN INDIA

[Source: Industry Estimates, with rounded off figures from graph on Page 51, Business World, March 1-14, 1989]

Source	Production (Million Tonnes)
SAIL	7
TISCO	2
MINI STEEL PLANTS	4
IMPORTS	1
TOTAL	14

CASE 6

PUNJAB TRACTORS LIMITED (R)

Company Background

Punjab Tractors Limited (PTL) was promoted by Punjab State Industrial Development Corporation Limited (PSIDCL) with the objective of promoting new industrial projects in the state of Punjab on 27 June 1970 at Chandigarh. The unit went into production in 1974. The tractor was based on completely indigenous design and was the result of six years of design, development and field proving effort at the Central Mechanical Engineering Research Institute (CMERI), a national laboratory under the Council of Scientific and Industrial Research (CSIR) of the Government of India. The group of design engineers, who had developed he first model at CMERI, were later transferred to PTL to commercialise the product.

During the period 1974 to 1980 PTL increased its production and sales from 58 to.7116 tractors, gross block from Rs. 31.53 million to Rs. 97. 25 million, net worth from Rs. 9.32 million to Rs. 51.10 million, gross income from Rs. 1.64 million to Rs. 345.54 million, earnings per share from nil to Rs. 16.08, number of employees from 518 to 2470, and market share from 1.0 per cent in 1974 to 11% in 1980. (See Exhibits 1 and 2 for some financial information.)

The character 'of the company has changed considerably during the last few years. In addition to manufacturing tractors, PTL now manufactures harvester combines and grey iron castings. Recently PTL entered into a technical and financial collaboration with Toyokogyo Co. Ltd. of Japan for manufacture of light commercial vehicles and a new company named Swaraj Vehicles Limited has been formed for this purpose.

This case describes the process of development of indigenous technology at CMERI and its subsequent commercialisation by PSIDCL and PTL.

About CMERI

The CMERI was established in 1958 at Durgapur in West Bengal as one of the links in the chain of national laboratories under the Council of Scientific and Industrial Research (CSIR) of the Government of India. The objectives of laboratories set up under, CSIR were:

i). Development of substitutes for imported raw materials.

ii). Indigenous manufacture of essential components hitherto imported.

iii). Development of indigenous know-how at a significantly advanced level to be commercially utilisable in respect of those articles on which repeated foreign collaboration has been sought.

iv). Orientation of industrial research to the needs and requirements of industry.

CMERI.'s activities were to be exclusively devoted to design, development and improvement of machinery and equipment, development and improvement of process technology, and evaluation methods for engineering products and materials. In 1965, it was organised under seven divisions: i) Applied Mechanics, ii) Applied Science, iii) Automobile Engineering, iv) Heat Power and-Refrigeration, v)) Materials vi) Product Development and Industrial Design, and vii) Production Engineering.

Aurora and Morehouse (1974) mention that:

> ... The preliminary work of developing the Institute, namely the buildings, ordering and erection of equipment, and recruitment of scientific and technical staff, took a long time. When Mr.G.S. Chowdhury became director-in-charge in 1962, the Institute's Professional staff was composed primarily of scientific and included only two mechanical engineers. During his tenure, Mr. Chowdhury was able to enlarge the staff of scientist-engineers and created several new research units related directly to industrial problems, such as industrial design, welding, automobile production and refrigeration. It was only in 1963 that significant activity in applied research began at the Institute. In

Case (1983, revised 1985) written by Prof, Shekhar Chaudhari, Indian Institute of Management, Ahmedabad. Used with permission. Case material is prepared to serve as a basis for class discussion. Cases are not designed to present illustrations of either correct or incorrect handling of administrative/managerial problems.

June 1964 Mr. Chowdhury was replaced as director-in-charge by M.M. Suri. He too was a person of outstanding energy and imagination... Within the first three years of his accession to the directorship, collaboration with industry increased remarkably (Table 1).

Table 1: Collaborative Agreements 1964-67

Year	Number of industrial collaborators	Initial fees received for industrially, spon- sored research in Rs	Fees received for the evaluation of products& materials in Rs.
1964-65	6	25,000.00	19,000.00
1965-66	24	175,000.00	17,000.00
1966-67	28	48,500.00	99,000.00

Demand for Tractors

Up to the end of the First Plan period, tractor requirements were met to a some extent by Indian firms assembling semi-knocked down packs in agreement with foreign principals. In 1955 a committee was appointed by the Ministry of Commerce to estimate the total demand for tractors. Exhibit 3 shows the estimates of tractor requirement by the year 1960-61. The Fourth Plan estimates made by the Ministry of Agriculture are shown in Exhibit 4. Exhibit 5 gives in concise form estimates made by a number of organisations.

The sudden increase in perceived demand for tractors could be, explained by the occurrence of Green Revolution in the mid sixties. The Indian Agricultural Research Institute made an interesting analysis of the power build-up required during the Fourth Plan period. This study highlights the fact that if the Fourth Plan food production targets were to be met, it was necessary to step up the power input into agriculture from 42.9 million H.P in 1965-66 to 111 million in 1970-71. The study, after looking into alternative sources of power, like human and bullock power, concluded that tractors and power tillers would be required to provide an additional 47.5 million H.P. in 1970-71. Their estimated tractor requirement is presented in Exhibit 6.

Government Policy and Development of the Tractor Industry

The Indian tractor industry is now more thari'25 years old. A beginning with indigenous manufacture was made in 1959 when the first tractor manufacturing unit was set up by Eicher Tractors Limited in Faridabad near New Delhi. Though indigenous manufacture was initiated as early as 1959 there was significant dependence on imports till the end of the sixties as could be seen from Exhibits 7 and 8. However, the industry has grown quite rapidly since the mid 70s and is now said to be the fifth largest in the world, In 1984 the tractor industry produced more than 80,000 tractors.

The various policies enunciated by the Government of India from time to time have played an important role in the development of the industry. In this section we shall try to explore the more important policies from the point of view of the tractor industry.

As seen in the section on demand for tractors, the real spurt in the perceived demand came with the onset of the Green Revolution. The introduction of high yielding seeds in the mid sixties in what growing areas of northern India and its adoption by farmers led to the need for mechanisation of forming activities and hence the demand for tractors spiralled.

Import of Tractors

Tractors were allowed to be imported by established importers, who were required to provide evidence that 1) they were accredited agents of manufacturers of imported tractors, 2) they had adequate workshop facilities and trained engineers to service the imported tractors, and 3) the makes of tractors to be imported by them had obtained specific official test certificate. Imports were allowed relatively easily till 1956, though certain procedural modifications were made because of the deteriorating foreign exchange position of the country. From 1957, besides the normal trade channels, tractors were imported through the State Trading Corporation largely from Soviet Russia and Czechoslovakia. During the period 1961-70, Russia, Czechoslovakia and Rumania were the major sources for imported tractors.

During 1971 and 1972 massive quantities of tractors were imported under a world Bank Scheme for financing integrated agricultural projects in India. However, from 1974 onwards import of complete tractors was stopped.

An interesting aspect is that prices of tractors imported from East European countries were substantially lower than those of locally manufactured ones. The Government was of the opinion that such a policy of .. import of low priced tractors would not hurt the domestic industry as imports were allowed to bridge the gap between production and demand.

Industrial Licensing

During the period 1960-61 four firms were granted industrial licences to set up tractor manufacturing units with a total capacity of 11,000 tractors per year. As a result of the increase in perceived demand for tractors, the Government allowed the existing manufacturers to increase their capacities and also licensed an additional private film and proposed to set up a public sector firm to manufacture tractors. The total licensed capacity in 1966 wad, .18, 500 tractors per annum. The sudden spurt in demand from 1966 onwards prompted the Government to delicense the tractor industry on February 7, 1968. Nine new projects were approved. However, again when the demand seemed to stabilise and the industry seemed to be becoming extremely ciewded by a large number of potential manufacturers, the Government brought the industry under the purview of industrial licensing in 1970. Ultimately, only a few projects finally materialised. During the period 1959-65, five firms set up plants for manufacturing tractors. In the second phase of the development of the industry six new units set up tractor manufacturing facilities. Two units were set up during the period 1981-83. Exhibit 9 gives the names of units, along with their collaborators and date of commencement of indigenous production.

Other Policies

1. To protect the interest of the farmers in a situation of shortage of tractors, the Government in 1967 imposed statutory control on selling prices of indigenously produced tractors. In 1971 the Government also imposed control on distribution of tractors. However, these controls were removed in 1974 and 1976 respectively.
2. To accelerate the pace of indigenisation the Government required new projects to give a plan of progressive indigenisation. Duties on imported components were raised considerably in 1969-70; however, in spite of heavy duties, imports from the East European countries were substantially cheaper than indigenously produced components. This hampered the pace of indigenisation.
3. To strengthen the demand for tractors the Government attempted to increase the credit facilities to farmers for purchase of tractors through directives to commercial banks to increase their proportion of rural lending and through expansion of rural branches. Agricultural development branches were created within commercial banks specifically for advancing rural credit. Re-finance facilities to commercial banks were analysed and special schemes for encouraging tractorisation were developed:

Genesis of SWARAJ

The story of SWARAJ ("Swaraj" means self-rule) tractor began in 1965 when the Fourth Five Year Plan was being formulated. One of the projects for which the Government of India was thinking of obtaining aid from Soviet Russia was the establishment of a plant for manufacturing a 20 H.P. tractor in India. Tractors in the lower horse power ranges were required in view of the pattern of landholding as shown in Exhibit 10. The aid envisaged to be obtained from Soviet Russia was both financial and technical. However, the Russians indicated their reluctance to assist the project.

Mr. M.M. Suri, who was then the Director of the Central Mechanical Engineering Research Institute (CMERI), was also a member of the delegation which visited Soviet Russia. He felt that the project as formulated had excessive foreign exchange content and required a large number of Russian experts, and that it was not warranted with large idle capacities with Mining and Allied Machinery Corporation (MAMC), Durgapur, and Heavy Engineering Corporation (HEC), Ranchi, two public sector firms. Mr. Sufi suggested to the then Deputy Chairman of the Planning Commission that CMERI could develop an indigenous tractor design that could be produced without external assistance or even imported parts.

The thinking of Mr. Sufi and his associates who were to take up the project later was that the Indian industry was essentially foreign collaboration based. The diversity of the sources of technology posed a great problem to Indian planners, steel manufacturers and the users of various engineering products. Each new imported technology imposed fresh ancillary burdens for diverse components. They (PTL document) gave the example of the diesel engines:

> ... India manufactures a larger variety of diesel engines than any other country in the world, even though the total production is comparatively small. Each ancillary manufacturer has thus to cater to a very wide range of designs, sizes, and specifications of components which increases the cost of indigenous manufacture. Such a growth of national production has imposed on the country the choice between dependence on component imports, or in the alternate uneconomic production...

Mr. Suri began a crusade advocating the development of indigenous technology and was successful in getting the Government's approval for designing an indigenous tractor at CMERI.

A Committee of Technical Experts (CTE), comprising representatives of the industry, agricultural universities, fanners and the Tractor Training and Testing Station ('1'11'S) at Budni was constituted in 1965 at CMERI for directing the design team.

Regarding the role of the Planning Commission in this, Mr. Chandra Mohan as quoted by Bhatt 1978 said:

> If I look back, it was not the Planning Commission which assigned the task to CMERI, It was virtually Mr. Sufi, who forced the Indian approach on the Planning Commission ...

The design team created at CMERI to work on the tractor project consisted of two production engineers, two design engineers, an industrial engineer, a foundry expert, a metrologist and two automotive engineers.

Development of Prototypes

The design team undertook intensive studies in the comparative merits of designs of various tractors available in the country. The tractor was to be engineered specifically for the Indian environment and to withstand Indian use and abuse.

The philosophy underlying the design may be gauged by the following statement (ibid):

> At the time when Swaraj designs were initiated at CMERI I had analysed that considering the immense popularity of the Massey-Ferguson, Swaraj must be fully competitive with it, if not better.

Swaraj tractor was built to suit local conditions - farmers required a tractor in I I.P. range of 2() to 30; such a tractor would mean lower capital and operating costs to the farmer. While explaining the basis of the design of Swaraj, Mr. Chandra Mohan (ibid) said:

> ... Economics of scale can only be related to the scale of production for any particular design and not when different designs are under consideration. Specific examples, which I may mention are:

1. Sheet metal (fenders, bonnets etc.) of tractors all over the world and more particularly from the developed countries, is so designed that it requires minimum tooling investments of Rs. 5 million and plant investments of Rs.10 million. Designs have been developed basically to save labour. On the other hand Swaraj sheet metal requires a tooling investment of not more that Rs. 10,(00 and it is being made in three small-scale units with investments of around Rs.1,00,000each.
2. The casting wall thickness for tractors in the developed countries has been so reduced over the years to save material costs that they can be produced in foundries with investments larger than Rs.1(X) million. On the other hand Swaraj castings developed specifically for technology levels readily available in India are being made in foundries with capital investments as low as Rs. 5,00,000... Our production costs with these designs are decidedly lower even at low production levels...

According to the top management of the organisation:

> ... Indian standard materials are used to ensure 100% indigenous content. Secondly, a suitable diesel engine already manufactured in bulk is engineered into the tractor to reduce project capital cost and administrative effort to nearly half. Thirdly, ancillary components, switches, clips, clamps, fasteners, bushes, bearings, electrical steering wheel, guages, etc., which are already being manufactured in India for some user or the other, are used in the Swaraj to avoid developing new ancillary components to the extent possible, so that the benefits of rationalisation can accrue to the manufacturers of SWARAJ.

Design Features

Swaraj tractor was initially built around a four-stroke, two cylinder, air-cooled engine that was being manufactured by the Kirloskar Group within the country. Later on, the management decided in favour of a water-cooled engine. The managing director of the company explained;

We did eventually decide to switch to a water-cooled engine, despite proven technological advantages of air-cooled engines. A casual remark of a very senior Punjab Government official made us take this decision: "As it is you are trying to market an unknown tractor based on Indian know-how: why open a second front by introducing an air-cooled engine with which our farmers have had bitter experience on some tractors earlier. One front at a time is better strategy..."

Some of the salient features of the original design (CMERI) were the following:

The tractor had a 20 HP diesel engine of French design with a rated speed of 2000 R.P.M. and a compression ratio of 16:1 with dual range four speed transmission so as to cover a wide variety of jobs ranging from heavy duty to fast transport, and a provision for an independent power take off unit which could be engaged or disengaged when the tractor was in motion and could be used as a prime mover for pumps and other similar equipment. Engine cooling was achieved by an axial blower. Implement movement was controlled by a hydraulic system with fingertip control. For improved traction in slippery and muddy spots a foot operated differential lock was provided. There was also provision for adjustment of front and rear axles, and manual steering,

Design Innovation

Availability of hydraulics was considered as a major requirement for a good tractor. Providing a sophisticated system with automatic draft and position control of implements without infringement of the existing patents posed a problem. The CMERI team successfully developed an original single lever automatic depth-cum-control hydraulic system, which is covered extensively by CMERI patents in India, U.K., Japan, West Germany, U.S.A., France, Poland and Yugoslavia. All known tractor hydraulic systems in the world employ two or more remote control levers for controlling the working of the hydraulic system. The Swaraj system is an improvement upon the existing design concept. The entire control is effected by single lever which leads to:

i). Easier training of the farmer for handling implement operation efficiently.

ii). Lesser chances of confusion during operation. Field 'resting of the Prototypes

Field Testing of the Prototypes

Test rigs were developed to carry out endurance tests on the front axles, engine, main castings, etc. to fully prove each one of these sub-assemblies prior to their assembly on the prototypes. The first prototype tractor was assembled in 1967 and was put to extensive endurance tests in CMERI lasting 1197 hours non-stop running with 10-30% overload during the hot summer months when the ambient temperature was as high as 49°C.

Three more prototypes were produced in March 1969 incorporating all the improvements that were found necessary during trials on the first prototype. These were sent for extensive field trials and performance evaluation at the Tractor Testing and Training Station at Budni, Punjab Agricultural University, Ludhiana (PAUL), and U.P. Agricultural University, Pant Nagar. Testing at Ludhiana and Pant Nagar not only covered the universities but also farmers. Tests extended over a period exceeding 1600 hours. The performance was very satisfactory and the farmers who had used this tractor were extremely happy.

At a meeting convened by the Additional Secretary, Ministry of Industrial Development and Internal Trade, on 22 February, 1971 where representatives of the Directorate General of Technical Development (DGTD), Ministry of Agriculture and the Director, Tractor Testing and Training Station, Budni, were present, the following points emerged:

1. The Director, TITS, Budni, noted that Swaraj tractor was better than most of the imported tractors with regard to drawbar pall and the ratio of drawbar H.P. to the power available at the power takeoff (PTO). These parameters were of primary concern to farmers.
2. Three main items which needed improvement were the steering, front axle and the hydraulic pump.
3. Steps had to be taken to submit RV2 engines made by Kirloskar Oil Engines Ltd. for testing them with regard to fuel consumption after certain modifications:

The improved versions of the three items mentioned in (2) above were evaluated by Director, 'I 11S during the period 17 to 22 May, 1971. Indications were that all the three items were satisfactory and were cleared for production.

SWARAJ Runs into Heavy Weather

While Mr. M.M. Sufi was advocating reliance on indigenous technology, the then Minister of Industries of the Government of India, Mr. T. Singh, went to Czechoslovakia, where he concluded an agreement with M/s. Motokov to prepare a detailed project. report on the manufacture and assembly of 12,000 Zetor 2011 tractors and some agricultural implements for a plant to be established at Ramnagar (Aurora & Morehouse op. cit). The report was submitted in March 1967 involving a capital investment of about Rs. 32.5 crore.

In the initial stages of development, Mining and Allied Machinery Corporation (MAMC), a public sector corporation at Durgapur, was expected to undertake the tractor project with the addition of some balancing equipment. But in the period of industrial recession in the country -1967 to 1971-MAMC incurred financial losses and was therefore not willing to take the additional risk involved in the manufacture of tractors (Chaudhuri, 1980).

At this time HMT, another public sector undertaking, was exploring for diversification opportunities. HMT perceived the tractor industry to be a promising field and hence suggested to the Government that it would like to take up the manufacture of tractors in the 2025 HP range. CMERI saw some hope of reviving Swaraj when HMT put forward its proposal to the Government.

The Government of India appointed the National Industrial Development Corporation Ltd. (NIDC), to prepare a project report with the following terms of reference :

i) To select the most suitable design for the tractor to be produced.

ii) The extent to which the existing facilities in HMT, Pinjore and MAMC, Durgapur could be utilised for manufacturing tractors.

iii) Additional investment involved and economic analysis of such a venture.

The NIDC submitted its report to the Government in April 1969, recommending the manufacture and assembly of 12,000 Zetor tractors of 25 HP at HMT, Pinjore.

The Swaraj tractor project seemed to fizzle out without any governmental support. The Planning Commission members who had shown interest when Mr. Suri had made the proposal to manufacture the 20 HP tractor indigenously had been changed by 1969. Mr. Sufi, who had spearheaded the initial phase of the project, left CMERI in 1969.

Revival of Swaraj

When all seemed.lost, help came from unexpected quarters. The Punjab State Industrial Development Corporation Limited (PSIDCL) had been familiar with the development of Swaraj; it had observed the field trials in Punjab and was aware of the farmers favourable response to it.

The PSIDCL is a wholly owned undertaking of the Punjab Government. It was specially set up in 1966 to promote large and medium sized industries in the State. It had already implemented successfully six industrial projects by 1970.

According to the Managing Director of Punjab Tractors Ltd., though PSIDCL was aware of these developments, they were not very enthusiastic about the project's success. Possibly, they were sceptical about indigenous technology. The Central Government which should have encouraged the development of indigenous technology, had cold shouldered Swaraj. The PSIDCL's risk-taking ability was also not very high. The design team of CMERI impressed upon the PSIDCL the inherent strength of the project, and the benefits that would accrue to Punjab, some of which seemed to be:

1. Indigenous design, specifically engineered for the Indian environment.

2. Favourable customer reaction during the tests in Ludhiana and Pant Nagar.

3. Employment potential in the factory itself and development of a multitude of ancillary units.

4. Injection of high technology and the development of quality conseiopsness in the small industries around.

The PSIDCL authorities, having been influenced by the thinking of the leader of the CMERI design team, promoted the Punjab Tractors Limited. The company was incorporated on 27 June, 1970 at Chandigarh and obtained the Certificate of Commencement of Business on 29 July 1970.

The know-how and technology development by CMERI, Durgapur, was licensed to PSIDCL through the National Research Development Corporation (NRDC) of India, New Delhi, a Government of India organisation. The conditions were:

1. Right to CSIR's Indian Patent Nos. 113114, 113115, 116257 and their corresponding patents in USA, UK, West Germany, France, etc.
2. Right to any further developmental work done by CMERI on Swaraj tractor and first options on work in a field allied to tractors.
3. A royalty of 2% on the net ex-factory sales price of the tractor excluding major bought-outs like the engine, tyres, tubes, rims, and electricals.(including dashboard instrumentation) would be payable to NRDC for a period of 10 years.
4. A royalty advance of Rs. 1 lath to NRDC to be adjusted subsequently.

Implementation Team

For the implementation of the tractor project, PSIDCL obtained the services of the team of engineers of CMERI, which had been working on the development of the tractor since 1965. The promoters felt that it was essential to have the services of the original design team for successful implementation of the project. The CMERI team had become wellknown for its dedication and commitment to the cause of indigenous technology.

Consultancy Services for the Implementation of the Swaraj Tractor

In the initial negotiation with the CMERI it was indicated that the major responsibility for translating the developmental know-thow into mass production technology would have to be taken by PSIDCL. This aspect was further emphasised during discussions between PSIDCL, NRDC and CSIR.

It was recognised that the development of production technology for Swaraj would require expertise of the highest calibre in every field: styling, jig and tool design and manufacture, stores and procedures, production planning and controls, material management, plant layout, etc. Two alternatives were available to PSIDCL:

i) Appointment of reputed consultants who would provide the composite engineering services for the project; and

ii) Building up PSIDCL's own cadre of experts.

The second alternative was dropped after detailed consideration, when it was recognised that full-time services of experts of the calibre required would be extremely expensive. Furthermore, it would not be possible to give these experts full tithe occupation, particularly after the project went into production.

It was then decided that the services of some reputed consultants would be retained for helping PSIDCL in executing the Swaraj tractor project and at the same time training its young team of engineers in all the facets of implementation.

The services of M.M. Suri & Associates (P) Ltd., New Delhi, a reputed consultancy firm headed by Mr. M.M. Suri, formerly with CMERI, were retained with effect from 3 September 1971 to provide comprehensive engineering services during the period of construction and six months of production thereafter at an approximate cost of Rs. 19.3 lakh. They were to be given the responsibility of training an adequate number of engineers and staff in all aspects of project execution, production, and management.

Competition

Some information on the industry has already been provided in the section on government policy. This section provides brief description of the major competitors of Punjab Tractors Ltd.

Eicher Tractors Limited (ETL)

This was the first company to commence manufacture of tractors in India. ETL was floated in 1959 in collaboration with Geier. Eicher of West Germany. The manufacturing operations started in a very small way. Starting with a single cylinder air-cooled tractor of 24 HP Eicher India now has developed improved models of the original tractor, It has also developed 35 and 12 HP tractors through its own efforts and the tractors are likely to be in the market soon. Beginning in 1960-61 with a production of 132, the company manufactured 13,650 tractors during 1983-84. The company's plant is located at Faridabad about 60 Km from New Delhi. The company set up a relatively large research and development centre at Faridabad during 1975-76, with departments specialising in engine design; tractor design, system design, transmission design, metrology, prototype development, materials science, and testing. The annual recurring expenditure is approximately Rs. 10 million.

Gujarat Tractors Limited (GTL)[1]

GTL was set up in 1961 in Vadodara by an erstwhile trading company, which was perhaps the first to introduce tractors into India in the twenties. Owing to poor financial performance GTL was closed down in 1971 and was then taken over by the Government. This company is presently manufacturing 50 HP tractors mainly and a 6171P tractor to a limited extent. The company had introduced a 35 HP Model in 1964 with imported powerpacks but the model was discontinued after 1975. The original 50 HP model is based on the know-how provided by M/s. Motokov of Czechoslovakia. GTL recently entered into a collaboration agreement with M/s. Polytechna of Prague for manufacturing Zetor 45 HP tractors. The 61 HP model which GTL, is presently manufacturing was developed through in house developmental efforts. After the takeover by the Government production has improved but been erratic. Production in 1971 was 211 tractors which increased to 2654 in 1978-79 but declined to 1150 during 1980-81. ,

GTL's R & D department was set up in 1972 after the takeover by the Government. It is still in its infancy. GTL has developed a 61 HP model which it has started marketing. The R & D section forms a part of the larger engineering department.

Tractors & Farm Equipment Ltd. (TAFE) (Based on Suri Report)

TAFE was engaged in distributing and servicing Massey Ferguson tractors before manufacturing it in 1961 in collaboration with Massey Ferguson. The factory is located in Madras. The company forms part of the Amalgamations Group, which manufactures automotive and industrial diesel engines, tractors and farm equipment, forgings, stampings, cutting tools, batteries, and automotive ancillary equipment such as pistons, liners, rings, and bimetal bearings. Commencing with a 35 HP model the firm introduced a number of other models which were assembled from imported kits. However, those were soon withdrawn from the market. In 1974 a 55 HP model was introduced but was given up in favour of a 45 HP model which along with the original 35 HP model are in production presently. By 1971 this company was producing close to 5000 tractors; however the production declined to about 2000 in 1973 but has again almost steadily increased to about 8000.

Escorts Limited and Escorts Tractors Limited

Prior to commencing manufacture of tractors Escorts was engaged in distributing Ferguson tractors. However, when the agency was terminated, Escorts Limited started selling a Polish made tractor known as Ursus. In 1966 their manufacturing operations began with a 27 HP model. Over the next few years a number of models were added by attaching prime movers of different horse power to the original transmission, which was considerably overdesigned. The engine was procured locally from an indigenous manufacturer, Kirloskar Oil Engines Limited. Later, Escorts started manufacturing the engine in collaboration with the Polish manufacturer. They now have 35 HP and 47 HP model, in production at their plant located at Faridabad near New Delhi. In 1970 Escorts, production reached a peak of more than 10,000 tractors, but declined due to certain field problems. It remained below 6000 tractors still 1976 and since then it has picked up to about 12,500.

Escorts Tractors Limited was promoted by Escorts Ltd. in 1969 in collaboration with Ford Motor Co. of U.K. to manufacture a 47 HP tractor. The factory is located beside the older plant in Faridabad. Starting with a production volume of less than 1100 tractors in 1971 ETL produces over 8000 tractors per year. Its market share is around 11%.

Mahindra and Mahindra Ltd.

The International Tractor Division of Mahindra and Mahindra (M&M) was initially floated as a separate company in collaboration with International Harvester of Great Britain and Voltas Limited Bombay. From the beginning till 1976 the company did very well when it suffered a major set back. It was then merged with M&M as one of its divisions. Besides tractors, M&M manufactures jeeps, light commercial vehicles, agricultural implements, and process control instruments.

The company started manufacture with a 35 HP model which even today is the dominant one in the product line. A 43 HP model was added during 1971-72 in collaboration with IH and a 50 HP model designed by ITC's own R&D department was introduced in the market during 1981-82. The production has picked up from about 2000 during 1976-77 to almost 16,000 tractors during 1983-84.

[1] This section is based on a report prepared by M/s. MM Suri & Associates Pvt. Ltd. 98

Hindustan Machine Tools Ltd.

Hindustan Machine Tools Ltd., a central government enterprise is one of the most well known state owned enterprises. It is engaged in the manufacture of a variety of machine tools, tractors, wrist watches, watch manufacturing machinery, printing machinery, lamps and lamp making machinery, etc., in 13 plants all over the country.

Tractor manufacture commenced in 1971. at Pinjore near Chandigarh in collaboration with M/s. Motokov of Czechoslovakia. Starting with a 25 HP model, HMT has added two more models to its product line. A 35 HP model, developed through in-house R&D efforts, and a 58 HP model in collaboration with Ws. Motokov were introduced during 1977-80. Till around 1980 the 25 HP model was the dominant one; however by 1983-84 the 35 HP model accounted for about 60 per cent of the total production of a little less than 12,0[1])0 tractors. The 25 HP model accounted for almost 40 per cent with the 58 HP one accounting for less than 1 per cent.

Kirloskar Tractors Limited

Kirloskar Tractors Limited (KTL) was promoted by Kirloskar Brothers Limited and Kirloskar Oil Engines Limited in 1970. It entered into a technical collaboration agreement with Ws. Klockner Huboldt Deutz of West Germany in 1970 for technical know-how for the manufacture of tractors. KTL belongs to the well known Kirloskar Group of companies, which is engaged in the manufacture and selling of diesel engines, machine tools, electric motors, and pumps. In spite of the fact that the product technology acquired by KTL is acknowledged as superior to many of the competing brands, KTL has been having financial problems because of poor sales performance from the very beginning. As a result it was merged with Kirloskar Pneumatic in 1982.

Production commenced with a 43 HP model during 1972-73. Since then, three other models of 75 HP, 35 HP, and 100 HP have been added to the product line. But the first one continues to be the dominant one. Beginning with a volume of 500 tractors per annum during 1972-73, KTL reached a volume of a little more than 2000 during 1980-81. However, the production declined to about 800 during 1982-83. The plant is located at Nasik near Bombay.

Financing of the Project

The detailed project report was completed by March 1971. The next problem was that of financing the project. PSIDCL and PTL approached the Industrial Development Bank of India (IDBI) and other financial institutions.

PTL submitted a project (capacity output of 5,000 tractors in 20-30 HP range) with a capital cost of about Rs. 3.7 crore (Table 2). They had planned a very high percentage of (80 per cent) boughtouts with only 15-20 per cent own manufactured components in order to reduce the capital cost of the project.

Table 2 : Swaraj Tractors : Project Cost

(Rs. Millions)

	Expected (March 1972)	Actual (April'74)
Land	1.162	0.985
Buildings	2.252	3.435
Plant and Machinery		
a) Imported	3.191	3.135
b) Indigenous	15.426	13.457
Technical Know-how	2.073	1.640
Miscellaneous Assets	0.781	2.337
Preliminary Expenses	4.480	0.583
Pre-operative Expenses	5.050	5.187

Provision for Contingencies	2.300	
Margin for Working Capital	4.287	5.187
Total	37.002	35.916

Source: V.V Bhatt, "Decision Making in the Public Sector Case Study of Swaraj Tractor", Economic and Political Weekly, XDI (21), (May, 1978).

The expected project costs were exceptionally low compared to most tractor manufacturing programmes. Plant and machinery costs could be kept low by ensuring high utilisation rate of expensive machinery. In the words of the Managing Director of PTL (Bhatt, 1978):

> A very critical contribution of indigenous technology is the in-depth flexibility which it provides to the design group to adopt/ innovate to bring down the costs keeping local conditions in view. This flexibility is further increased by their indepth knowledge of the production processes. We have in our own case changed designs of components to cut down capital investments any number of times. Complementarity of the production group has also shown immense flexibility in selection of machines and stretching them to the limits of their capabilities to conserve capital, a scarce commodity in a developing country. We are perhaps the only unit in the world where in special purpose machines which are normally tooled up for the production of one or two components, have been stretched out to handle 4 to 5 components. Our utilization of these expensive SPMs had 100% utilisation at production levels of 400 and as we proceed further to higher production levels, we will keep on adding SPMs. Capital investments for us will always be made as the market demands higher production levels[1]

The PSIDCL was agreeable to contribute at the most 10 per cent of the project cost, while the IDBI's rule of thumb was that the promoters should finance the project at least to the tune of 15 per cent of the total cost through their own resources. The PTL team suggested that the Punjab Government and G,S. Atwal's combined shareholding would'satisfy IDBI's conditions. However, complications arose when IDBI took the decision that G.S. Atwal & Co. had to be dropped and PSIDCL's equity had to be increased to satisfy its conditions. Almost one year went by before PSIDCL could be convinced into taking this decision.

Some of the striking arguments made by the PTL team which won the case in their favour were (Company Document, PTL)

> ...This project has been worked out taking full advantage of the traditional dynamism of the ancillary industry of the Punjab, their initiative and their extreme competitiveness.4-lowever, their presently poor reputation as regards quality with resultant high rejection (which only increase the component costs) has to be overcome by providing technical assistance... to develop their manufacturing skills for precision working, heat treatment, etc. Having taught one supplier the right manufacturing process all concerned can rest assured that in the Punjab the technique will spread around the area through worker enticement defection etc., generating keen competition from the area as a whole. This strategy perhaps could not be deployed in any other region of the country with the same confidence as in the Punjab. The planned spillover of high technology for achieving quality production of the Swaraj would raise the quality standards throughout Punjab where production costs are lowest in the country. If quality is also assured, the Punjab ancillary would be like Japan, hard to compete in any international market. Swaraj is treated as a catalyst for the spread of precision technology which offers to the Punjab ancillary outlets around the world for component suppliers. Already western countries, especially West Germany, are poised as large buyers if quality could be ensured. Thus the project approach has wider horizons than the mere successful setting up of Swaraj tractor manufacturers by the Punjab Tractors Ltd. Permeation of high technology throughout the Punjab industry... is aimed at.

At one stage PTL was confronted with questions regarding the passibility of the project's attaining 100 per cent rated capacity in the second year of the project. The design team gave the following reasons for their optimism in achieving a rapid rate of production build-up.

[1] Source: V.V. Bhatt, "Decision Making in the Public Sector: A Case of Swaraj Tractor," (Domestic Finance Studies No. 48, Feb. 1978), World Bank.

1. The design itself is evolved around major assemblies which were already in production in India and where no new capacity/technology/tooling is to be established either by the ancillary manufacturers or by PTL.
2. Ancillary manufacturers, particularly for the hydraulic system and 3-point linkage, were associated with the development of these, assemblies ever since 1967. This four-year- association has given them a major understanding of the technological problems involved in the development of these components.
3. The technological skills which have been generated within PTL by the availability of the CMERI team which has worked on the development of each and every component of the tractor over the last six years. This experience is further heightened by the fact that the development was done with established industry and not within a research laboratory.
4. The design know-how and experience available with PTL which will enable PTL not only to educate the ancillary industry in the supply of components and the requisite quality standards but also enable them to modify the designs for adaptation of scientific components which may already be under manufacture in India.
5. The two years of construction schedule of the project is a period dictated primarily by machine deliveries. This construction schedule is typical only to our project because of its 100 per cent indigenous content and is not applicable to any of the other tractor manufacturers, who because of the availability of CKD components start assembly operations within the first year itself. This early commencement of production with CKD supplies and the phased deletion programme thereafter delay the attainment of rated production levels.
6. The extensive pre-planning that has gone into the project since 1968 from the manufacturing point of view, the location of the sub-contract facilities for components, tooling, spare machine capacity, etc.
7. The component that is there behind the project of the CMERI team which is determined to make the Swaraj project a true and effective symbol of the emergence of national technology. It will be appreciated that a committed management/technological team will go a long way towards overcoming any hurdles that are likely to be experienced in the implementation of such a major project:

The company was successful in making arrangements for underwriting and long-term loans with the IDBI, Industrial Finance Corporation of India (IFCI), Industrial Credit and Investment Corporation of India (ICICI), Life Insurance Corporation of India (LIC), and the Unit Trust of India (UTI) under which the financial institutions agreed to provide underwriting assistance to the extent of Rs. 85 lakh (equity and preference) and long-term loans totalling Rs. 230 lakh. The Government of India also took the decision to participate in the equity capital of the company to the extent of Rs. 8.5 lakhs, which was ultimately routed through HMT, Bangalore.

Project Implementation

IDBI, a major partner, was very impressed with the performance of the project on various dimensions: meeting target date of completion; keeping within expected project cost at a time of rising material prices, raw material shortage, financial stringency; and reaching full capacity in the expected time (See Table 3).

Table 3: Some Performance Indicators

	Expected	**Actual**
Capital Cost (Rs. million)	37.002	35.916
Costation Lag	105 weeks	105 weeks
	(March 1972 to	(March 1972
	March 1974)	March 1974)
Output/Sales of Tractors		
1974-75	1600	933
1975-76	3500	2242
1976-77	4500	3196
1977-78	5000	4003
Operating Profit (Rs. Million)		
1974 75	-.3.656	-8.82

1975-76	-0.320	+0.57
1976-77	1.761	+11.89
1977-78	2.702	+13.34

This was achieved through management action in various areas as explained by the Managing Director:

> In Punjab Tractors Ltd. (PTL), completion within project estimates was a total commitment, This commitment in a situation where prices started rising abruptly at an alarming rate inspired us to explore every conceivable avenue towards cost saving in all aspects of the project...

To save on construction costs, PTL adopted a large number of innovations in building technology, some for the first time in industrial construction, even though all these technologies had been proven extensively in other fields of civil engineering.

Once the project was commissioned, the one goal uppermost in the mind of management was to reach full capacity utilization. Some problems arose in reaching this target :

1. Development of reliable vendors to cater to the very steep production growth curve.
2. Technical problems of the product.
3. Manufacturing problems.

Development of Reliable Vendors

PTL has developed about 125 ancillary units out of which 60 per cent have been promoted by PTL,' the remaining 40 per cent being those existing in small units which were located and given support to manufacture Swaraj components.

Out of the 750 components, approximately 60 are made by PTL. The largest single item is the engine (about Rs. 12,000 or 25-30 per cent of the retail price) which comes from Kirloskar of Pone,

Approximately 50 per cent of the components come from large scale enterprises. Components like tyres, tubes, batteries, wheels, radiators and clutches come from suppliers all over India, Out of 125 small and medium scale enterprises supplying components to PTL, 40 are within a distance of 1 km from the plant and another 40 are in Chandigarh. Proximity has several advantages : ease of communication, better quality control, and greater continuity in supplies, Some 50% of PTL's components come from such enterprises, although in rupee value the share is much less.

Initially PTL found it difficult to convince potential vendors to take up manufacture of Swaraj components. During this period PTL started manufacturing a large number of components within its premises to somehow increase production. Production facilities had been planned to manufacture only 70 to 80 components. When it was utilised for manufacturing several times this number the production of complete tractors was naturally small. A separate vendor development cell was created, which reported directly to the Managing Director. Its role was to develop entrepreneurs from fresh engineering graduates in order to meet component requirements of an increasing production volume. In 1978 PTL received the ASSOCHAM award for ancillary promotion.

Technical Problems

To cope with teething problems on the product a Product Servicing Group was created. It reported to the Marketing Manager, and worked in close coordination with R &D. Later it was brought under R & D .

Manufacturing Problems

The assumptions of 90 per cent machine utilisation and 90 per cent operator efficiency which had been made while planning for facilities did not come out to be correct and balancing machinery had to be purchased. Also third shift working had to be introduced. Third shift working has its attendant problems of poor discipline and low efficiency. Experienced workmen could not be recruited as salary bills had to be kept low. Machinery selected was more of the general purpose type which required high operator skill, which could only be developed over a period of time. Special jigs and fixtures had to be designed to do-skill the operations.

Marketing Swaraj

By 1974 the tractor industry was facing a major depression. In addition there. were 11 manufacturers in the fray, which had resulted in the market's transition from a sellers' to a buyer's one. In the initial stages Swaraj faced some resistance as explained by the Managing Director (1979):

> This project is the first large scale tractor project in India based on .100% Indian . knowhow and technology. There was some initial resistance in accepting the Indian knowhow by both the central and state governments since it had never been tried before. When we proposed to manufacture the tractors, a foreign collaboration agreement was acceptable to everyone but our project which was 100% indigenous was not.'

PTL faced a challenging task in marketing Swaraj. When PTL began its effort in the selection of dealers, the factory was still under construction and prospective dealers were doubtful about the company's ultimate success. PTL's management realised that product performance, product quality and reliability, and easily-accessible servicing facilities were critical dimensions in a competitive market which would dictate customers' decision-making.

PTL did not begin lining up dealers until the end of 1973 and the beginning of 1974. By mid 1975 it had 19 dealers in a 200 mile radius of Chandigarh. By the end of 1976, it had 80 dealers spread all over the country. Out of the roughly 10,000 tractors sold by mid 1978 over 80 per cent had been sold in Punjab, Haryana, Delhi and U.P.

When the tractor market was very tight in 1975-76 and 1976-77, PTL began experimenting with incentives to dealers. If a dealer sold over 100 tractors in a year, he would get a seven-day paid vacation in Kashmir. If he sold over 150 tractors he would get a ten-day vacation in Goa. During tight condition PTL began exploring diversified uses and outlets for its tractors-as road-masters for transport and haulage, without the hydraulic lift for Rs. 2,500 less. PTL was also exploring the use of the tractor as a hydraulic lift platform for fixing street lamps and electric transmission lines.

PTL provides a one-year guarantee on its tractors. Most other tractors carry only a six-month guarantee.

Servicing is of course critical to building up a satisfactory group of customers who in turn are the product's best salesmen. PTL has three service centers with personnel and dealer coverages as indicated in Table 4 below.

Table 4: Swaraj Service Centres

Centre	Dealer Coverage	Staff
Chandigarh	52	24
Lucknow	29	6
Bhopal	19	1

PTL is also trying to establish auxiliary service centres in small towns. PTL's input is to provide training for the mechanics.

The Director's report for 1976 stated:

To cater to a larger market spectrum the product range was enlarged in November 1975 with the introduction of a new 35- HP tractor, the Swaraj-735. Swaraj-735 has been developed by the company's own R&D and is again 100 per cent indigenous. Exhibits 11 and 12 give comparative prices of tractors of different makes.

Research and Development

Research and development is of prime importance to this company. The whole project was started because of Mr. Surf's faith in indigenous technology. The manager of the R&D department said:

[1]"Professional Profile- The Man. Behind Swaraj," Business India, April 16-29, 1979, p. 38.

We strongly believe that for our country to develop at a fast rate India R&D is a must and products suitable for Indian conditions and at suitable prices can best be done by R&D in India. The founding of our company has been based on this bask principle itself. Our company started with the purpose of using indigenous design for manufacture and consequently R&D was .set up at the start of the company.

In fact it was the tool room which was the first block to be commissioned on 16 August 1972. From October, two-shift working began for manufacturing jigs and fixtures. Perhaps PTL is the only company in the tractor industry to have started with a R&D department from the very first day. Tool room facilities were to be used for the manufacture of jigs and fixtures and other toolings and prototypes of new products.

The usual practice with regard to manufacture of jigs, fixtures, and tools in the tractor industry is that special purpose machine tools are purchased from the manufactures in completely tooled up condition but the jigs and fixtures for the general purpose or universal machinery are partly manufactured within the plant and partly sub contracted. The function of the tool room in the tractor industry is that of maintenance of these special tools as and when required. But in the case of PTL, a deliberate policy decision was made to manufacture all jigs and fixtures for general and special purpose machinery within the plant itself in order to reduce costs. The designs of the jigs and fixtures were made by PTL engineers with the aid of their consultants. Tractor manufacturers having foreign collaboration could get ready-made designs which had to be modified to suit Indian standards. In many cases they could import complicated jigs and fixtures from their principals. Tool room facilities in India are scarce and therefore difficulties crop up in developing reliable sources of high quality jigs and fixtures. Also their cost is exhorbitant. According to a very senior officer of the company, the cost of manufacturing these jigs and fixtures for PTL was less than half of what they would have cost in other places.

Table 5 shows yearwise.capital and recurring expenditure on R&D activities.

Table 5: R & D Expenditure (Rs. in Lakhs)

Year	Capital	Recurring
1972-73		0.41
1973-74	3.00	1.26
1974-75	0.30	"3.65
1975-76	0.52	3.94
1976-77	0.80	4.70
1977-78 (est.)	11.0&	5.10

Capital expenditure has gone towards purchase of certain instruments and building of a small shed. Plant and machinery for R&D.has-not been set up in a separate shed.because of the company's policy of conserving scarce capital. Tool room facilities are used for R&D work and the coordination for the use of the common facilities is done at the managerial level, but when there are complex situations the priorities are given by the Managing Director. Research and developmental work does not follow a smooth pattern. At certain times there is a very heavy work load and at other times the utilisation rate of machinery may not be more than 15-20 percent. For this reason R&D work is generally scheduled whenever the load in the tool-room is less and by this arrangetnent extra capital investments have been avoided.

Even without its own production facilities R&D's achievements have been quite remarkable in terms of the new products it has developed, and design improvements made on existing products for cost reduction and quality enhancement. The department has to its credit several types of agricultural implements in addition to the new model of tractors, i.e., Swaraj-735 (39 HP) and Sartaj, the economy 'model, which uses a single cylinder engine of about 17-18 HP. About 80-90 per cent of all the new products developed by the R&D Department have been commercialised and all the company's products are products of its own R&D. Already work has begun on developing a 50-HP tractor, to be called "Samrat". PTL will have then the most complete range of tractors ranging from 18 HP to 50 HP

Organisational Set-up and Training

PTL has a functional structure with the Managing Director as the head. The CMERI team which developed Swaraj Tractor formed the core of the project management team with. four of them heading four of the functional areas which were found most suitable to them. A few experienced persons were taken over the production planning, maintenance, technology, tool room, marketing, finance, etc. A phased recruitment of personnel was planned to reduce personnel expenses. Particular attention was given to the provision of engineers in every major activity. This was done with the idea that attachment of trainee engineers right from the inception of each activity would groom them into the very rationale of each plan and its subsequent execution. The idea was that in the two years during project implementation, this would build up a core of young, enthusiastic and competent engineers who would be able to shoulder responsibilities for further expansion with full confidence and technical capability.

The training of the engineers consisted of a certain period of on-the-job apprenticeship in tool room and design. Design was given special emphasis including jigs and fixture design because the management believed that injection of these disciplines activated processes of thinking and emergence of ingenuity. Quality control is the primary importance. The Manager (Quality Control) reports directly to the Managing Director to ensure strict and impartial observance of high standards of products. Even when the Manager, materials, develops the ancillary supplies, the Manager, quality control, is the independent authority to check on the quality of the supplies.

The Manager, R & D, also reports directly to the Managing Director in addition to the Director, Finance. Manager,' Materials, also reports to Director, Finance. The Works Manager and Manager, Special Assignments who looks after new investment planning and export marketing, report to the Managing Director. The partial organisational structure is shown in Figure 1.

Questions

1. What were the forces that led CMERI to take up the 20 HP project?
2. What factors were responsible for delay in the successful completion of the project?
3. What problems were faced in developing the technology and how were they overcome?
4. Evaluate the strategy of P'I'T., including its technology strategy.
5. What lessons can we draw from this case?

Appendix

TRACTORS

A tractor is a self-propelled vehicle capable of pulling a load. It is usually powered by an internal combustion engine, and is used on highways and in factories; but its greatest use is on agricultural land.

Basically, a modem farm tractor consists of an internal combustion engine, a transmission or gear reduction and selection unit to change engine power to torque at various speeds, main drive gears for further speed reduction, a differential unit to apply equal torque to each rear drive wheels at all times, and the drive or traction wheels. These units may be self-supporting by bolted to each other, suspended in a framework or by a combination of these methods of assembly. An engine clutch is necessary in order that the transmission gears maybe stopped to "shift" gears and to absorb the load without breakage or engine stalling.

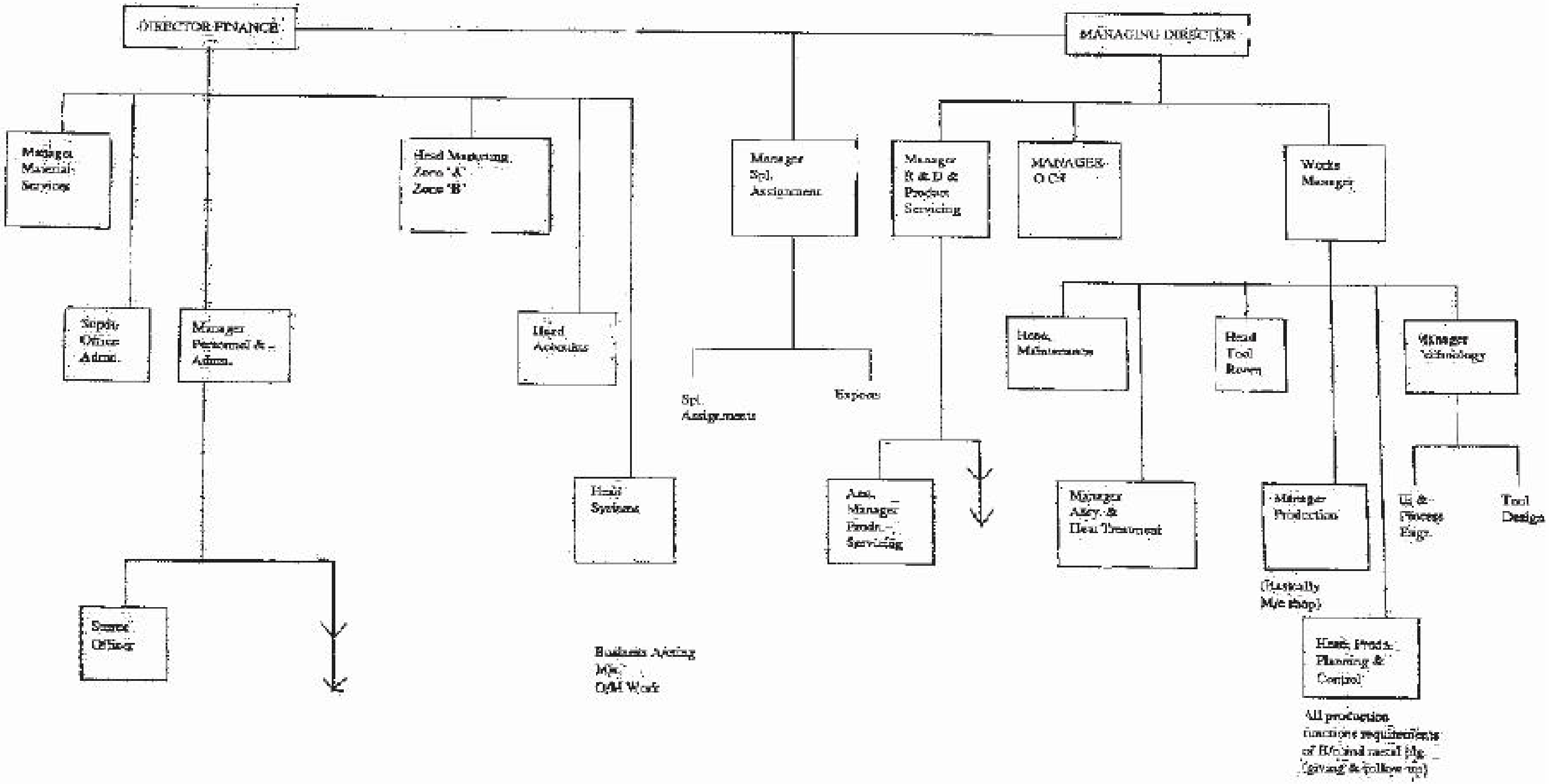
-There are 4 to 8 gear ratios-incorporated in tractor transmissions with travelling speeds ranging from approximately 24 to 15 or 20 miles an hour.

Tractors are equipped with high capacity air cleaners because of the extremely dusty conditions in which they operate. AU are equipped with belt pulleys and power take-off shafts and many have some type of hydraulic lift system. The power take-off shaft is a powered shaft extending at the rear of the tractor from which an extension transmission shaft can be used to operate trailed machines such as a combine.

Tractors can be classified according to their main functions such as farm tractors, industrial tractors and highway tractors..

The farm tractor has revolutionised the mode of farming wherever it has been used. It has relieved fanners of arduous work and made great increases in production possible. Through the use of the tractor, farmers can control power that is equivalent to many horses and men. The average man is rated at 1/10 H P, but when he drives a 20 HP tractor across his fields he is doing the work of 200 men. Tractors are used for a variety of purposes such as ploughing; harrowing, sowing, harvesting, pumping, and transporting.

Figure I
Partial Organization Chart (1978)



PUNJAB TRACTORS LIMITED
Summarized Income Statement

(Rs. in thousands)

Sl. No.		1973-74	1974-75	1975-76	1976-77	1977-78
1	Product Sales	1,625.65	30,548.73	83,814.87	1,29,675.99	1,71,286.42
2	Other Sales	6.38	772.42	60.37	90.18	71.73
3	Other Income	2.80	37.56	394.99	188.79	725.65
4	Total Revenue (1+2+3)	1,634.83	30,663.52	84,270.23	1,29,954.96	1,72,883.80
5	Consumption of Materials	1,247.31	24,724.82	64,781.36	97,019.86	1,21,882.47
6	Excise Duty	136.09	2,689.99	1,865.62	20.13	10,843.96
7	Operating & Administrative Expenses	983.88	5,880.31	9,727.18	13,723.91	19,853.58
8	Finance Charges	572.68	3,862.84	4,871.63	4,589.43	2,364.62
9	Depreciation	—	2,328.96	2,454.29	2,708.99	3,801.08
10	Total Expenses	2,939.96	39,486.92	83,700.08	1,18,061.52	1,58,745.71
11	Profit for the year (before tax) (4-10)	—1,305.13	—8,823.41	570.14	11,893.44	13,338.09

EXHIBIT 2

PUNJAB TRACTORS LIMITED
Summarized Balance Sheet For a Decade

Particulars	1970-71	1971-72	1972-73	1973-74	1974-75	1975-76	1976-77	1977-78
Assets			*43.037					
Fixed Assets	0.454	11.635	136.355		321.760	307.835	302.833	300.155
Current Assets, Loans & Advances	2.188	16.849	87.788		197.951	352.446	360.707	414.808
Miscellaneous Expenditure	4.807	15.434	5.836		150.690	146.179	47.695	1.960
Profit & Loss Account	0.031	—	—		—	—	—	—
Total	7.470	43.970	273.016		670.407	806.460	711.236	716.882
Liabilities								
Share Capital	7.000	37.500	138.910		139.815	139.815	139.815	139.815
Reserves & Surplus	—	0.002	0.002		46.271	48.503	53.176	114.984
Secured Loans	—		117.535		363.817	383.624	302.096	191.090
Unsecured Loans	—	0.392	—		26.050	44.410	17.175	17.000
Current Liabilities & Provisions	0.470	6.075	16.570		94.454	190.109	198.973	253.992

Note : Errors in totals are due to rounding off *(1972-73) — Unallocated Capital Expenditure.

EXHIBIT 3

Estimated Demand for Tractors by 1960-61

H.P. Range	Nos.
12-18	1,500
20-30	3,000
35-45	500

Source : *Report on the Fixation of Prices of Agricultural Tractors.* (Bombay: Tariff Commission, 1967), p.6.

EXHIBIT 4

Estimates of Tractor Demand

Sl. No.	Year	Nos.
1	1966-67	20,000
2	1967-68	25,000
3	1968-69	30,000
4	1969-70	35,000
5	1970-71	40,000

Source : Adapted from Fourth Plan estimates quoted in *Tariff Commission Report*, 1967 (Estimates made in 1966-67),p.27.

EXHIBIT 5

Tractor Demand—Estimates for 1973-74

	Upto 25 HP	26/35 HP	36 HP & above	Total
Planning Commission				
Ministry of Agriculture:				
a) 1968 Estimates	21,000	38,000	9,000	68,000
b) 1972 Estimates	25,000	45,000	20,000	90,000
	—	—	—	40,000
Loading Tractor Manufacturers:				
a) Estimate 1968	10,000	40,000	15,000	65,000
b) Revised Estimate-1972	—	—	—	36,000
Indian Society of Agricultural Engineers :				
Estimate 1968	—	—	—	52,000
Actual Demand 1971-72 :				
a) Production	1,301	22,168	—	23,469
b) Imports	10,000	4,000	—	14,000
c) Total	11,301	26,168	—	37,469

EXHIBIT 6

Tractor Requirements Achieving Fourth Plan Targets as Estimated on I.A.R.I

Sl. No.	Horse Power Range	Nos.
1	6–10	500,000
2	12–16	500,000
3	22–24	500,000
4	28–36	200,000
5	44–50	50,000

Source: *Tariff Commission Report*, 1967, P. 31

EXHIBIT 7

Import of Tractors (1961-1974)

Year	Imports (Nos.)	Total Availability
1961-62	2,997	13,877
1962-63	2,616	4,030
1963-64	2,349	4,332
1964-65	2,323	6,646
1965-66	1,989	7,703
1966-67	2,591	11,407
1967-68	4,038	15,432
1968-69	4,276	19,742
1969-70	10,478	28,598
1970-71	13,300	33,399
1971-72	19,739	37,839
1972-73	1,000	27,802
1973-74	1,000	21,435

Source : Adapted from B.K.S. Jain "Production of Agricultural Machinery in India," (Paper presented at the International Rice Research Conference, Manila, April 19 to 23, 1971) p. 8 (Estimate made in 1968) and S. Kumar Deb, "Indian Now an Exporter," *Commerce*, (February 28, 1976), pp. 271-72.

EXHIBIT 8

Production of Tractors

Number of Tractors Produced

	Tractors											
	FTIL	EL	EIL	GTCL	HIL	HMT	KTL	M & M	PTL	PTPL	TAFE	TOTAL
	EGL	Escorts	Ford	Hindustan	Harsha	Zetor	Kirloskar	International	Swaraj	Pittie	Massey Ferguson	
1960	59	—	—	—	—	—	—	—	—	—	—	59
1961	202	—	—	—	—	—	—	—	—	—	395	597
1962	269	—	—	—	—	—	—	—	—	—	1,308	1,577
1963	36	—		485	—	—	—	—	—	—	1,124	1,645
1964	235	445	—	1,355	—	—	—	—	—	—	1,716	3,751
1965	113	1,055	—	1,270	—	—	—	225	—	—	2,935	5,598
1966	153	2,115	—	1,870	—	—	—	550	—	—	3,400	8,070
1967	122	2,109	—	1,805	—	—	—	2,669	—	—	3,819	10,524
1968	346	4,269	—	2,032	—	—	—	3,818	—	—	3,336	13,801
1969	329	8,120	—	1,971	—	—	—	4,329	—	—	3,344	18,093
1970	788	9,665	—	1,402	—	—	—	3,835	—	—	2,267	19,937
1971	878	5,204	1,053	344	—	617	—	7,603	—	—	3,412	17,111
1972	780	2,481	1,823	703	—	2,578	—	10,161	—	—	1,420	19,946
1973	969	4,887	2,838	310	—	3,557	—	9,302	—	—	1,494	23,557
1974	1,196	5,133	3,403	750	—	5,704	506	9,230	380	93	2,351	28,746
1975	1,563	4,651	4,701	766	982	6,549	754	7,399	1,508	94	3,430	32,378
1976	2,854	5,259	5,010	1,565	588	6,553	325	6,348	3,001	105	4,842	36,450
1977	3,485	7,142	5,500	2,056	1,028	4,132	232	1,932	3,272	101	5,727	34,627
1978	5,159	10,377	6,673	2,552	731	9,190	600	7,077	4,541	300	6,201	53,399
1979	7,011	12,246	7,428	2,100	523	8,441	1,027	9,405	6,355	279	4,975	60,190
1980-81*	11,164	11,266	7,304	1,150	795	8,105	2,087	13,401	8,929	N.A.	7,794	71,995
1981-82	12,710	13,478	7,286	2,146	897	11,034	1,235	13,751	9,420	N.A.	8,862	78,819
1982-83	10,573	9,211	7,375	729	245	9,890	784	11,901	5,310	N.A.	8,258	64,276
1983-84	13,650	12,208	8,611	1,335	185	11,780	1,563	15,901	10,285	N.A.	7,632	83,150

* From 1980 onwards the figures are for financial year April to March

Source: Association of Indian Automobile Manufacturers.

Note: From 1955-1959 the production of tractors was 'nil'.

EXHIBIT 9

Indian Tractor Manufacturers

Period: 1959-65	Date of Commencement of Commercial Production	Name of Collaborator
1. Eicher Tractors Limited Faridabad	1959	Gebr. Eicher, West Germany
2. Gujarat Tractors Limited (Erstwhile Hindustan Tractors Limited) Vadodara	1963	Motokov Czechoslovakia
3. Tractors and Farm Equipment Limited, Madras	1964	Massey Ferguson, U.K.
4. Mahindra and Mahindra Ltd. Bombay (Erstwhile International Tractor Co. of India Ltd.)	1965	International Harvester, U.K.
5. Escorts Ltd., Faridabad	1966	Motoimport Warzowa, Poland
Period 1971-75		
6. Escorts Tractors Ltd. Faridabad	1971	Ford, U.K.
7. Hindustan Machine Tools Ltd., (State owned Central Govt.) Pinjore	1971	Motokov, Czechoslovakia
8. Kirloskar Tractors Ltd., Nasik	1974	Klockner—Humboldt Deutz, W. Germany
9. Punjab Tractors Ltd., Chandigarh (state owned)	1974	Indigenous know-how
10. Pittie Tractors, Poona	1974	Indigenous Know-how
11. Harsha Tractors Ltd., Ghaziabad		Motoimport, USSR
Period: 1981-83		
12. Auto Tractors Ltd., Pratapgarh (state owned)	1981	British Leyland, U.K.
13. Pratap Steel Rolling Mills Ltd., Ballabhgarh.	1983	Indigenous know-how

EXHIBIT 10

Distribution of Operational Landholdings by Size

Size	1961-62 Holdings No. (Millions)	%	Areas Hectares* (Millions)	%	1970-71 Holdings No. (Millions)	%	Area Hectares* (Millions)	%
Marginal (0 to 1 ha)	19.8	39	5.1	7	35.7	51	14.5	9
Small (1 to 2 ha)	11.5	23	16.4	12	13.4	19	19.3	12
Semi-medium (2 to 4 ha)	10.0	20	27.6	21	10.7	15	30.0	18
Medium (4 to 10 ha)	7.1	14	41.6	31	7.9	11	48.2	30
Large (10 + ha)	2.3	4	38.6	29	2.8	4	50.1	31
Total	50.7	100	133.3	100	70.5	100	162.1	100

Source: For 1961-62: *National Sample Survey*, No. 144, 17th Round, Cabinet Secretariat, Government of India, New Delhi, 1968.

For 1970-71: I.J. Naidu, *All India Report on Agricultural Census*, Government of India, Ministry of Agriculture & Irrigation, New Delhi, 1975

One hectare = 2.47 acres

EXHIBIT 11

Tractor Retail Prices (Rs.)
(20-30 HP)

Year	Eicher	Swaraj 724	Zetor
1970	17,480		
1971	19,460		
1972	25,200		
1973	27,720		
June 1974	30,410	27,720	30,400
Sept. 1974	30,700	30,700	30,700
Nov. 1974	30,700	33,330	31,200
April 1975	30,700	33,330	35,500
Oct. 1975	30,700	31,516	35,500
Jan. 1976	30,700	35,516	35,500
May 1976	30,370	37,000	35,500
Aug. 1976	30,370	37,000	36,700
May 1977	30,370	37,000	38,570
1st Jan. 1978	30,370	37,000	38,570
Sept. 1978	32,170	41,313	40,947

Source: Company Documents.

EXHIBIT 12

Tractor Retail Prices (Rs.)
(30 – 40 HP)

Year	Escorts E – 3036	Escorts E – 335	International IH – 275	Massey Ferguson MF – 1035	Swaraj 735
1970		17,291	19,570	21,140	
1971		18,896	22,890	24,250	
1972	25,200	25,200	25,200	26,300	
1973	27,720	27,720	28,930	28,930	
June 1974	30,410	30,410	31,710	31,710	
Sept. 1974	32,000	32,000	32,000	32,000	
Nov. 1974	36,528	36,528	37,750	38,207	
April 1975	36,528	36,528	43,250	43,497	
Nov. 1975	36,528	36,528	43,250	43,497	41,423
July 1976	36,528	36,528	43,250	43,550	40,830
Jan. 1977	41,791	40,613	43,250	43,104	40,830
April 1977	43,150	40,613	43,250	43,104	40,830
Jan. 1978	44,015	41,425	43,250	43,104	40,830
Sept. 1978	48,617	44,851	47,352	46,566	45,734

Source: Company documents

CASE-7

RICE HUSK BOARD

In 1974 a working group on wood and wood based industries appointed by National Committee on Science and Technology, Ministry of Science and Technology, discussed the problems faced by such industries. The committees took stock of R&D activities in wood based industry and suggested the identification of suitable alternative material to replace wood products and initiation of related R&D work. The report was discussed in a meeting held on 4th April 1977 under the chairmanship of the Secretary, Department of Science and Technology (DST). The DST after careful scrutiny sponsored the project "Development of Reconstituted Panel Products from Ligno cellulosic Material" and identified the Indian Plywood Industry Research Institute (IPIRI), Bangalore to take up the research. The financial outlay earmarked was about Rs. 7.82 lakh for a period of 3 years which was further extended for a period of six months at the request of IPIRI.

Wood Industry: Search for Alternatives

It is well recognised that the increasing demand for sawn wood and panel material in the country cannot be met from the existing forest resources. The projected requirements for industrial wood are expected to be of the order of 4, 41,550 tonnes* by the year 2000, against the actual production of 3,30,260 tonnes in 1990. Considering the fact that forest regeneration is proceeding at a very slow pace, it is unlikely that forests alone could provide the raw materials required for the mechanical wood products industries. The growth rate in the mechanical wood products industries has been slow.

In all the developed countries, particle board has succeeded to a great extent in meeting the shortage of sawn timber. The general trend the world over in wood based panel industries is to produce more particle boards because of the more efficient way of utilizing wood resources. In our country particle board industry has been slowly establishing itself as an alternative to sawn wood. However, even waste wood or inferior quality wood has become scare due to depletion of forest resources. There is, therefore, need to develop appropriate technologies for making panel material using ligno cellulosic agricultural residue, such as rice husk, cotton stalk etc. The purpose was to identify suitable renewable agricultural waste to manufacture particle board to replace wood to conserve natural resources and thus preventing depletion of forest and environmental degradation.

Product Identification and Research

Indian Plywood Industries Research Institute (IPIRI), Bangalore, had undertaken research work in 1977 to develop particle board using ligno cellulosic agricultural residue such as rice husk, groundnut shell etc. The purpose was to identify suitable renewable agricultural waste to manufacture particle board to replace wood to conserve natural resources and thus preventing depletion of forests/environment. The project was financed by Ministry of Science and Technology. The research work involved development of suitable resin for binding the particle and development/identification of machinery for the manufacture. Laboratory work was completed in 1982 and it was also established that rice husk is a good alternative material for use in the manufacture of particle board.

Industrial researchers in India and other countries have tried for the past few decades to manufacture particle boards from rice husk. However, it is the work done at Indian Plywood Industries Research Institute (IPIRI), ,Bangalore, with financial research grant form Ministry of Science and Technology in late 1970s, that has formed the basis for the development of rice husk board technology. In India, rice husk is available to the extent of 30 million tonnes per year. This will steadily increase with expansion in paddy cultivation to feed an increasing population. This technology offers complete utilisation of agricultural waste to manufacture value added building material and also to help conservation of forests. The depletion of forest reserves is a major concern for environmentalists as it has been the root cause of famines in Africa and some parts of Asia.

Rice Husk Board is the first product of its type developed for the first time in India as an effective substitute for wood based panel boards. The patented technology from IPIRI has been assigned to NRDC for commercial

*Source: DSIR Report October 1991

Case (1991) prepared by Dr S.T. Narayana Swamy, Chief Engineer, National Research Development Corporation, New Delhi.

Case material has been prepared to serve as a basis for class discussion. Cases are not designed to present illustrations of either correct or incorrect handling of managerial problems.

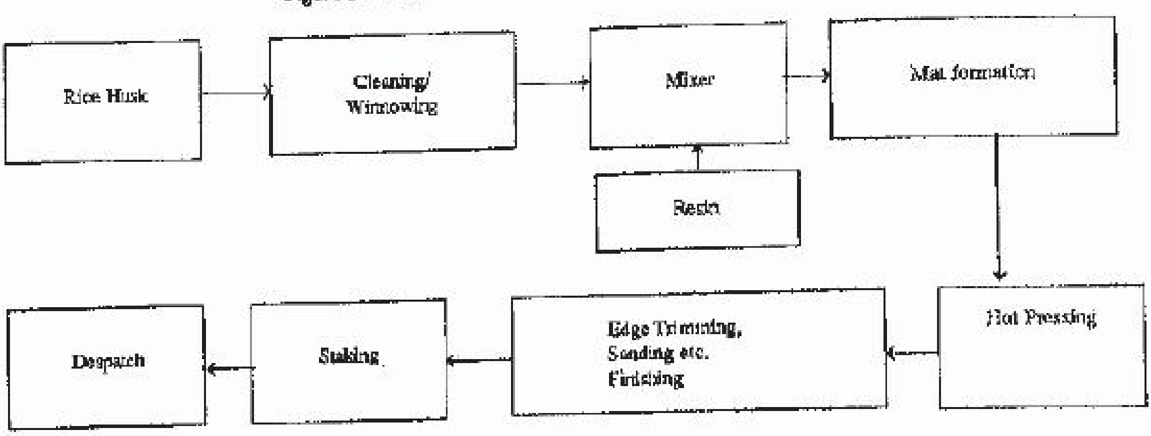
exploitation. The technology was licensed in 1988 to an entrepreneur in Bangalore to put up a commercial plant. The NRDC has extended interest free developmental loan to the firm under its `Technology Development Programme to meet the project cost. NRDC has also extended engineering support to the project. The project was jointly monitored by the Corporation and the entrepreneur. The unit came into production within a record time of 18 months. Presently the firm is in regular production and has developed variety of products to meet different applications. The product is well accepted in the market as a substitute for wood based panel boards.

Product Technology

The product technology is explained below:

Process of Manufacture: The process of manufacture of rice husk board includes, cleaning of husk as received from the rice mills, wind shifting to remove dirt and stones. The cleaned rice husk is coated with adhesive in a specially designed resin blender. The coated rice husk is spread on mild steel cauls sheets as an even mat. The process is called mat forming. These mats are transferred to hot hydraulic press. The platen of the hydraulic press are heated to desired temperatures and specific pressure is applied for a predetermined period. The boards are taken out form the press and the edges are trimmed to the desired dimensions. The boards may also be sanded to obtain smooth finish. A flow diagram of the manufacturing process is shown in Figure 1.

Figure 1: Process Flow Chart for Manufacture of Rice Husk Board



Development of Resin: The critical factor in making particle board from rice husk is the adhesive used in binding the particles. The IPIRI has done extensive research work in modification of phenol formaldehyde resin adhesive for bonding rice husk into particle board suitable for tropical climate. For rice husk board manufacture, part of the phenol in phenol formaldehyde resin is replaced with less costly cashew nut shell liquid (CNSL) or cardanol. It is noteworthy that CNSL is also an agricultural product and only a part of the potential annual production of 20,000 tonnes finds industrial uses at present. The thermosetting phenolic nature of the adhesive confers on the board its resistance to water and contributes to its durability.

Particle Boards: Specification of Uses/Applications

Rice Husk Boards are manufactured in various densities, thickness, types and grades to suit a wide range of applications. The manufacturing process, based on highly innovative technology, ensures quality in the total sense.

Some of the uses/applicationsare shown in box 1.

Box 1: Some Uses/Applications of Rice Husk

Wall panelling Medium density boards, both plain and overlaid decorative in any thickness, can be used as wall panels in any situation without fear of decay, insect or termite attack.

Doors, furniture windows, table tops Plain and overlaid decorative medium density boards can be used instead of wood- based boards. The boards when used as the core for flush doors and window shutters ensures freedom from insect attack, the so-called "dry rot".

False ceilings Low density tiles make attractive false ceilings. Thermal insulation and sound absorption are added advantages.

Roofing panels	Medium and high density boards make excellent pre-fabricated, light-weight roof panels for low cost housing, roof terrace houses etc. because of their resistance to decay and more important fire.
Insulation	Low density boards can be used as thermal insulation material in refrigeration and containers.
Partitions and stage settings	These boards being fire resistant and low cost are advantageous for use in partitions and for construction of stage settings.
Industrial and domestic flooring	Its high abrasion resistance makes it ideally suited for floorings.
General purpose	It is specially designed as a general purpose board for a host of applications where strength combined with freedom from wood-borers is required.

The Rice Husk Boards can be manufactured tailor made to suit the different applications. These boards are ideally suited for high technological applications such as audio-speakers, air-conditioner decks, auditoriums (acoustic applications) etc.

Rice Husk Board with bamboo mat finish is ideally suitable for shuttering work. These boards are re-used for more number of times compared to conventional plywood boards.

Properties of Boards

Rice husk boards have the same distinctly advantageous properties (shown in Box 2) when compared to wood • particle boards and other similar panel materials,

Box 2: Properties of Rice Husk Board

Termite resistance	It has been tested and proven that rice husk board is termite-resistant even when exposed to termites in a termite mound for years
Decay resistance	In a tropical country like India, where panels come into frequent contact with moisture in all forms. Rice Husk Board has a distinct edge over wood-based boards- because rice husk is in itself decay resistant. And this is further improved by decay-proof synthetic resin adhesive used
Fire resistance	The naturally inherent fire resistance of rice husk is further increased by compacting the husk to a high density. In fact no other material with equivalent properties is available in such large quantities for mass use in multi-storeyed buildings where fire resistance is an imperative requirement
Rodent resistance	Basically a gritty material, rice husk becomes grittier material, rice husk adhesive and bonded in the form of dense boards. This makes it difficult to gnaw at, and rodents stay away- a quality that makes specially useful in food grain and other storage applications
Technical superiority	Internal bond strength, elasticity, dimensional stability, screw and nail holding capacity, abrasion resistance, surface hardness in Rice Husk Board scores over conventional wood-based materials. In fact through intensive R&D checks and practical applications, the long-lasting features of Rice Husk Boards have been proven time and again

Economics of Production

Rice husk is abundantly available raw material and it may be described as virtually inexhaustible. Although it is ar agricultural by-product, it is not seasonal but is generated throughout the year in rice mills. The rice husk has, at present, no significant industrial use except as a boiler fuel in some places. It is practically wasted, by and large. Several rice mills are faced with the problem of disposal of rice husk. Therefore, the cost of rice husk would not, at any time; he expected to go higher than the cost of firewood. Also the size of particles of rice husk which come from the mill is satisfactory for board manufacture. The energy consuming operations of chipping and drying are not required for rice husk. Subsequent board manufacturing operations are similar for both wood particle boars and rice husk board. The same plant can produce low density. insulation board to high density boards required for varied applications. Therefore, the cost of rice husk board is 25 to 30 per cent cheaper than the wood based particle board.

Technology Transfer

National Research Development Corporation (NRDC) is a premier technology transfer agency in the country. The laboratory scale technology was referred to NRDC for commercial exploitation. Over the years, number of attempts were made to identify a suitable entrepreneur for upscaling the technology. The Corporation was ready to sanction interest free development loan under its technology development programme. But it was only in 1988, an enterprising promoter (Padmavati Panel Boards Pvt. Ltd., Bangalore) came forward to take up the project. He is an engineer and a successful builder. He was aware that the product could be used in building industry. The urge to undertake manufacture of new product and to succeed was his motivation.

Upscaling

The upscaling of the technology was done in two stages. First smaller size boards were manufactured using 2' x 2' Hydraulic Hot Press. All the process parameters were carefully documented. The boards were tested for various properties as required under Bureau of Indian Standards for wood based particle boards. The test results were satisfactory. Some boards were made into doors and other building products and put into actual use. The product met the requirements of the wood based particle boards and was accepted by the users. Encouraged by the results, standard size hydraulic hot press (8' x 4') was installed along with the additional balancing equipments required for regular production. The production started during the beginning of 1990. The product husk board-has better properties when compared to wood based particle board. It has application in buildings, furniture etc. It is an innovative product successfully developed in India for the first time in the world.

Project Monitoring

A Monitoring Committee consisting of representatives of NRDC, IDBI, IPIRI and the Promoter was constituted. The committee met once in three months, sometimes, earlier to monitor the progress of the project. The committee was able to identify weak areas in the project and helped in overcoming the same. This has given encouragement to the promoter and made him confident in the development of the technology.

Manufacture of Plant and Machinery

There are number of particle board plants working in the country. But the entire plant and machinery were imported along with technical knowhow. Therefore, it was one of the task to develop indigenous equipments for the manufacture of rice husk boards. The important equipments required are:

- Mat Forming Machine
- Resin Blenders
- Material Handling Equipments
- Hydraulic Multi Daylight Hot Press
- Finishing Line Saws
- Wide Belt Sanders etc.

The capacity of the plant was kept deliberately low to disperse the manufacturing plant at different locations. The transportation cost of bulky raw material is more expensive than the finished product. Therefore, efforts were made to develop plant and machinery to meet small capacity production at a reasonable cost.

Mat formation is an important part of the manufacturing activity. This is a continuous process and there is no indigenous manufacturer. Development of a suitable manufacturer takes time and trials. Therefore, manual mat formation with vibrating table system was adopted. The system is simple, less costly and meets the requirement of small volume production.

There are a number of units manufacturing resin kettle and blenders. The resin kettle is widely used in many chemical industries. The blenders are manufactured as per the specific requirement. Similarly manufacture of material handling system including loading and unloading system for the hydraulic press were entrusted to 2-3 parties. Their past experience in fabricating similar system for imported particle board project was very useful.

There are a number of firms manufacturing multi daylight hydraulic hot presses for plywood and lamination units. .The expertise of such firms was considered and they were encouraged to develop suitable press for rice husk board project. The necessary technical input was given by IPIRI and other experts in the field. Presently there are 3-4 parties capable of manufacturing this vital equipment for the rice husk board project.

The circular saws required for finishing line and belt standers were suitably modified to meet the requirement of husk board characteristics. Special carbon tipped cutting teeth for the saw were developed.

The entire range of plant and machinery required for the project is indigenously available. This has helped in reducing the project cost.

Market Strategy

The Rice Husk Board is a new product and requires considerable efforts in introducing it into the market. The boards, first introduced in the form of finished product, were later converted into doors, windows and used wherever possible. The boards were also used in partitioning, false ceiling etc.

Also a number of new products were developed to suit the varied applications. The acceptance of the product is increasing day by day. Presently, the boards are marketed through converters who directly use the boards to manufacture finished products.

Documentation and Technology Transfer

The technology has caught the imagination of general public and government agencies. The process is presently licensed to 10 firms in different parts of the country (Some firms are listed in Exhibit I). In about 12 months time, complete technology transfer shall be made available. The technology transfer consists of the following documents/stages:

- Providing technical knowhow documentation
- Providing specification of plant and machinery along with name and address of the manufacturer
- Specification of raw material and name and address of the supplier
- Training of the licensee personnel at the existing commercial plant to impart "hands-on" experience
- Commissioning of the plant to produce quality product.

Technology Innovation

The research and development of Rice Husk Particle Board is an example of a radical innovation in new product development. It replaces well known and commonly used wood and wood based particle board in day-to-day application, The research has taken considerable time, The patten of further innovation has taken long period and showed a very general feature of technological progress which followed the "technology S-curve".

Anticipating technological change is an important management function. Introduction of new product and new market awareness is a radical departure. They are hard to plan.. However, incremental innovations or improvements to the existing product have often been planned over a period of time. Figure 2 shows the general shape of rate of technology change. At the research stage, the rate of technological progress is exponential as a plethora of new ideas and alternative possibilities are generated. Later the rate of technological change slows to a linear growth. Finally, the rate turns off to little or no growth , as a natural limit to the technology is approached. (The different stages of development of a new product and efforts required to make it technically feasible and commercially viable case explained in detail in some units of the course on Technology Management).

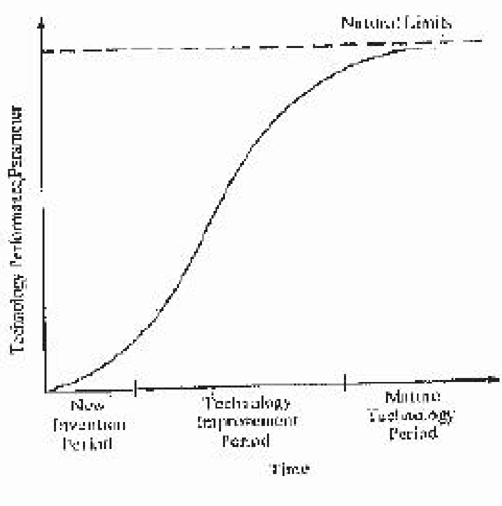


Figure 2: Technology S--Curve

Let us summarise the whole case. The Ministry of Science and Technology had recognised the need to develop alternative material (identification of new Product)' to prevent depletion of forest resources and degradation of environment. A specialised research institute capable of undertaking research project was identified. The required finances were made available to undertake research work. The task of technology transfer was assigned to NRDC which had long experience in the field. Provision of requisite finance and the commitment on the part of the promoter has made the transfer of technology smooth and project a success.

Monitoring of the project was an important management task which was expected to ensure better coordination in technology transfer. All the process parameters were documented and detailed specifications of the plant and machinery were made available to the licensee. These factors contributed in successful and smooth transfer of technology.

Questions

i) Make out a case for augmenting the use of Rice Husk Particle Boards in India.

ii) Have the Particle Boards become popular in India? Give reasons in support of your answer. (For your answer you may collect information from business Journals/manufacturers/dealers in particle boards.)

iii) Discuss the role of NRDC in developing and transferring technology for manufacture of Rise Husk Boards,

iv) Critically examine the policy of NRDC in transferring technology (it first transferred technology to one manufacturer, later on to some other manufacturers also).

v) What is precisely meant by upscaling of Technology? How was upscaling achieved in this particular case?

vi) What is the most critical component in the process of manufacturing of particle boards? How was the problem in this respect overcome?

vii) Critically examine technology S-Curve. Must all technologies follow bell-shaped S-Curve.

Exhibit 1: List of Some Firms Licensed to Manufacture Risk Husk Particle Boards

1. B.R. Agro Boards Pvt. Ltd., Hyderabad
2. Prithvi Panel Boards Pvt. Ltd., Nagpur
3. Advance Particle Boards Pvt. Ltd., Bombay
4. Punjab Boards Pvt. Ltd., Gurdaspur Distt.