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.

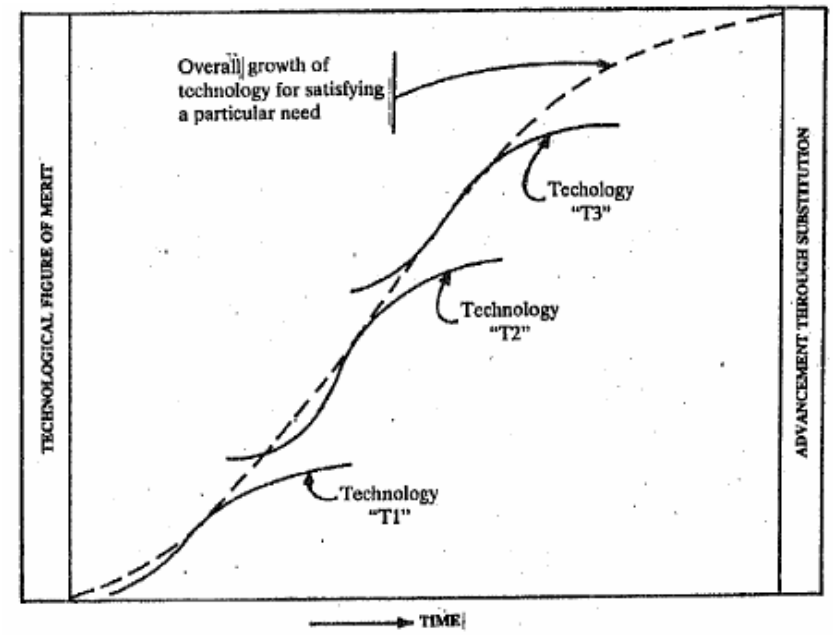

Figure it : S-shaped growth of technologies
Source: Technology for Dcvelopment)UN-ESCAP,1948.

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'.

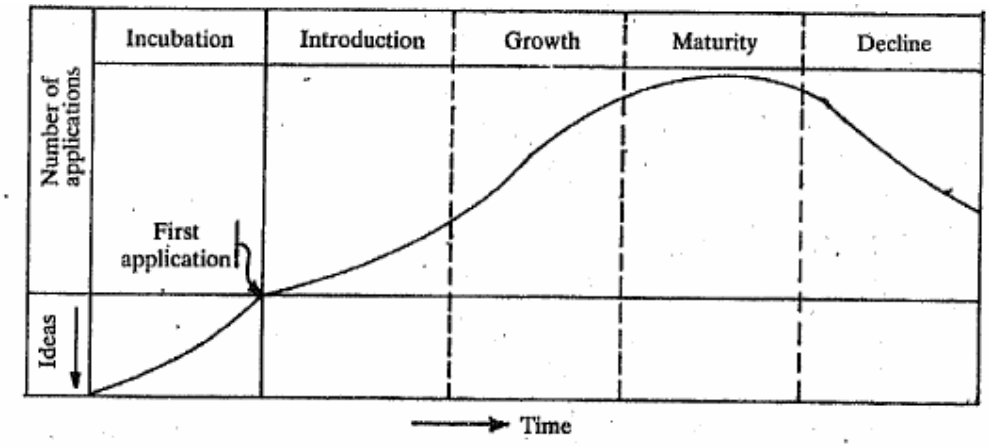

Figure 2.2 Phases In the technology diffusion process
Source: Technology for Development, UN-ESCAP,1984p7.

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.

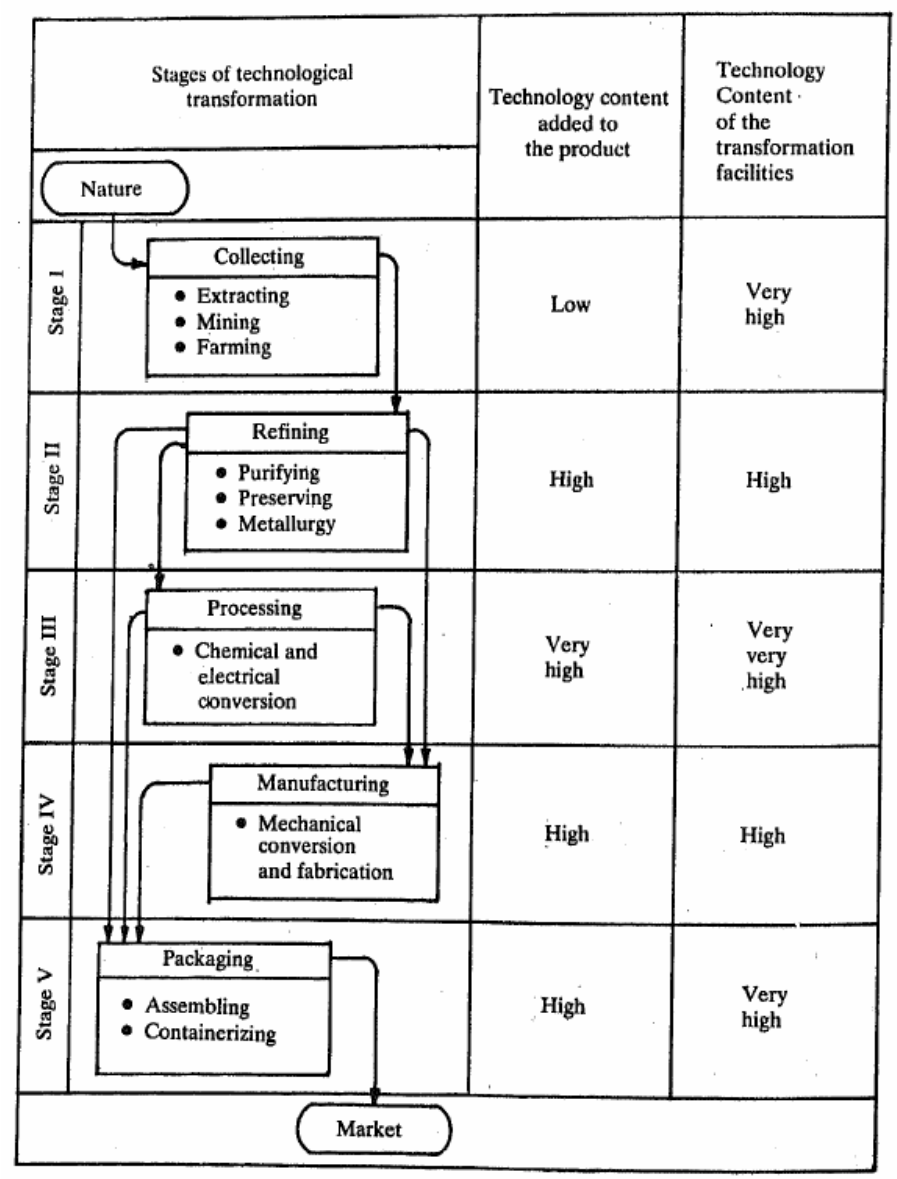

Figure 2.3 : Five stages of technological transformation in the production of goods
Source: Technology for Development UN-ESCAP,1984 p 11.

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.

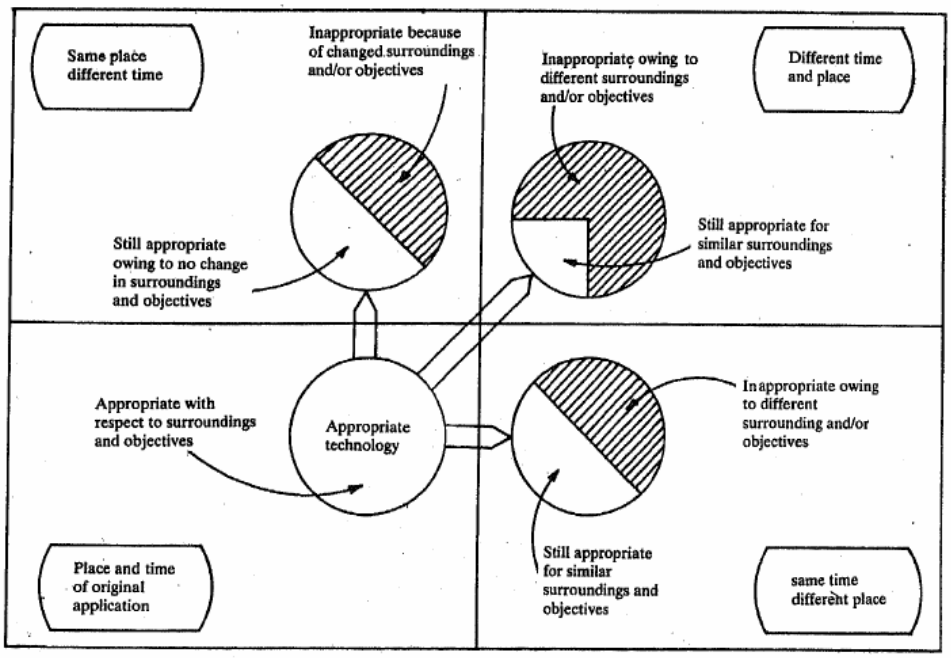

Figure 2.4: Appropriate and inappropriate technologies
Source: Technology for Development UN-ESCAP,1984, p87.

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,

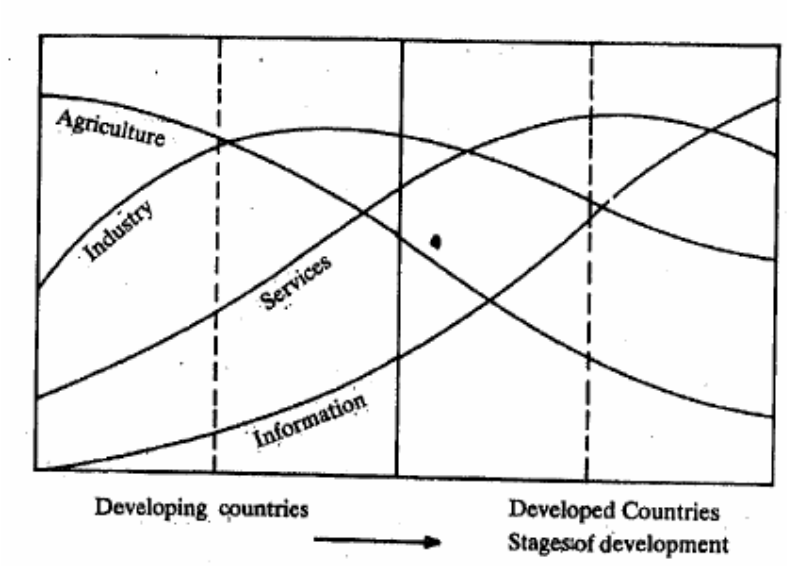

Figure 2.5 : Changes in the structure of the economy with technological advancement
Source: Technology for Development UN-ESCAP, 1984, P26.

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 iri 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.

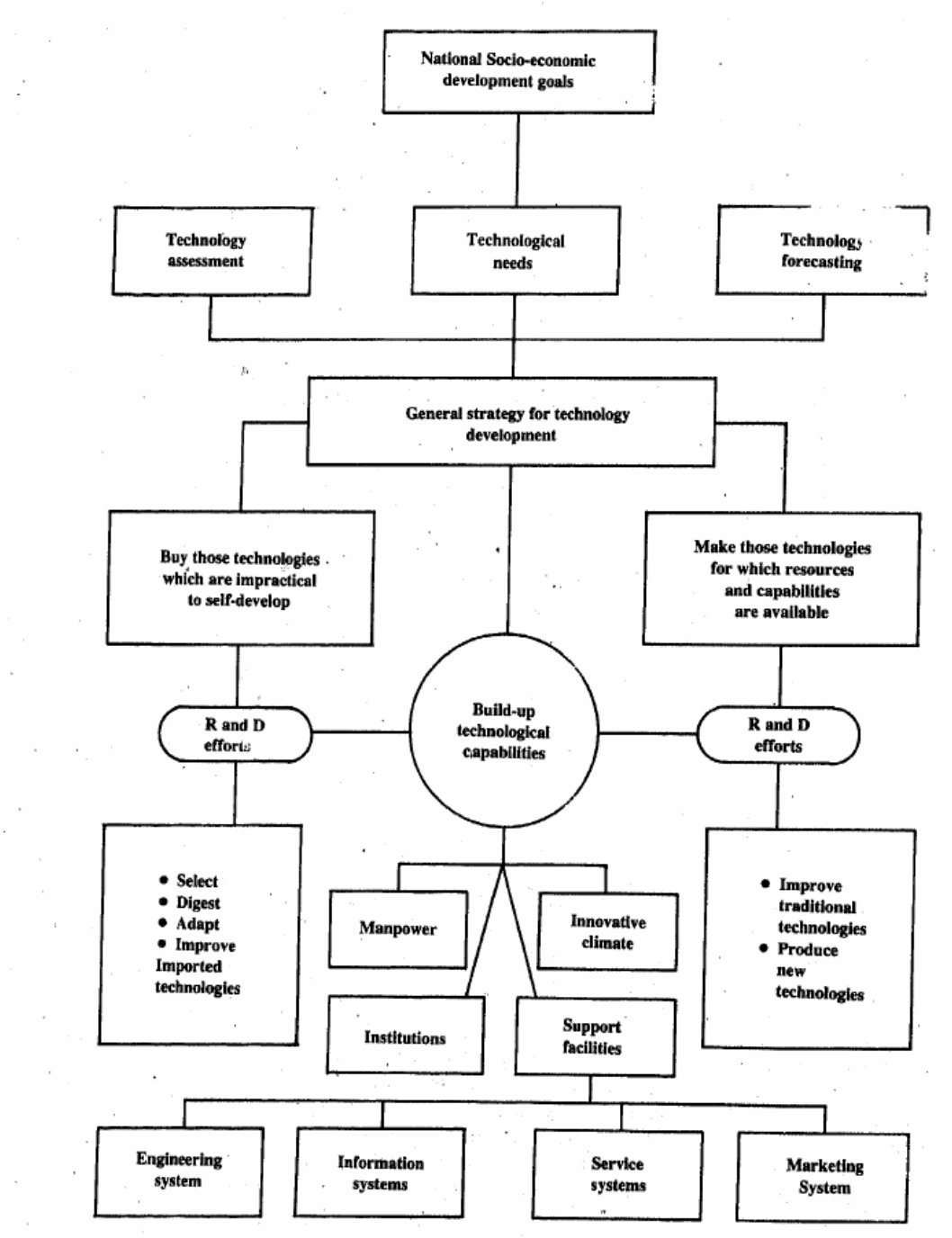

Figure 2.6 : The process of Technology Development
Source: Technology for Development, UN-ESCAP 1984, p: 30.

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.

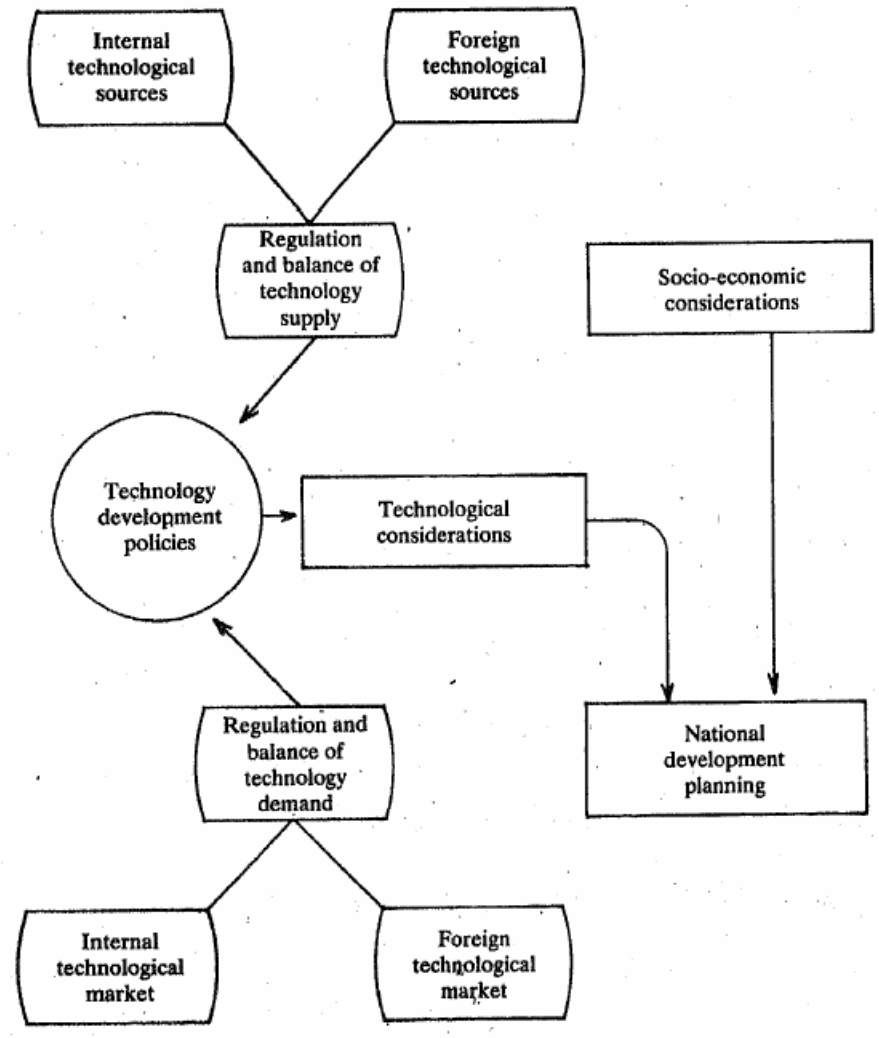

Figure 2.7 Integration of technological comdderetionu in national development planning
Source: Technology for Development, UN-ESCAP,1984, R34.

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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