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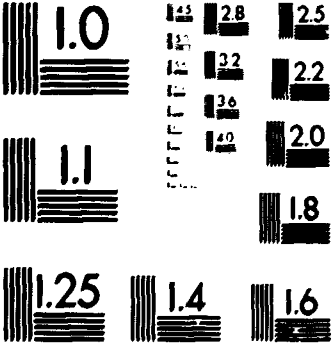

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ID/WG.442/4
26 April 1985
ENGLISH

United Nations Industrial Development Organization

Second Consultation on the Capital Goods Industry with Special Emphasis on the Energy-related Technology and Equipment

Stockholm, Sweden, 10-14 June 1985

DEVELOPMENT OF ELECTRIC POWER EQUIPMENT SECTOR AND TECHNOLOGY UNPACKAGING

Background document to Issue II *

Prepared by the UNIDO secretariat

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This document is partly based on a study prepared by UNIDO Consultant Mrs. J. Parikh.

CONTENTS

CHAPTER 1
INTRODUCTION

1.1 Background information

1. The First Consultation on the Capital Goods Industry was convened at Brussels, Belgium in September 1981 1/. The Industrial Development Board of UNIDO (IDB), at its sixteenth session, took note of the conclusions and recommendations of the First Consultation and decided at its seventeenth session that a consultation on capital goods industry with special emphasis on energy-related technologies and equipment be held during the biennium 1984-1985 2/.

2. The preparatory work for the Second Consultation has been planned in line with the recommendations of the First Consultation and the above-mentioned decision of the IDB. The preparatory work, therefore, covered two main areas; development of capital goods industry 3/, and energy-related technology and equipment.

3. The wide coverage of energy-related technologies and equipment (see Figure 1.1) has made it necessary to review them in order to identify the areas which could be discussed at the Second Consultation. This review was made at the expert group meetings which were held at Vienna, Austria, 10-12 October 1983 and 19-21 December 1983. These meetings, after considering several alternatives, have recommended that electric power equipment industry should be selected for further study 4/.

4. In line with the recommendations of the above-mentioned expert group meetings, UNIDO has carried-out the following activities:

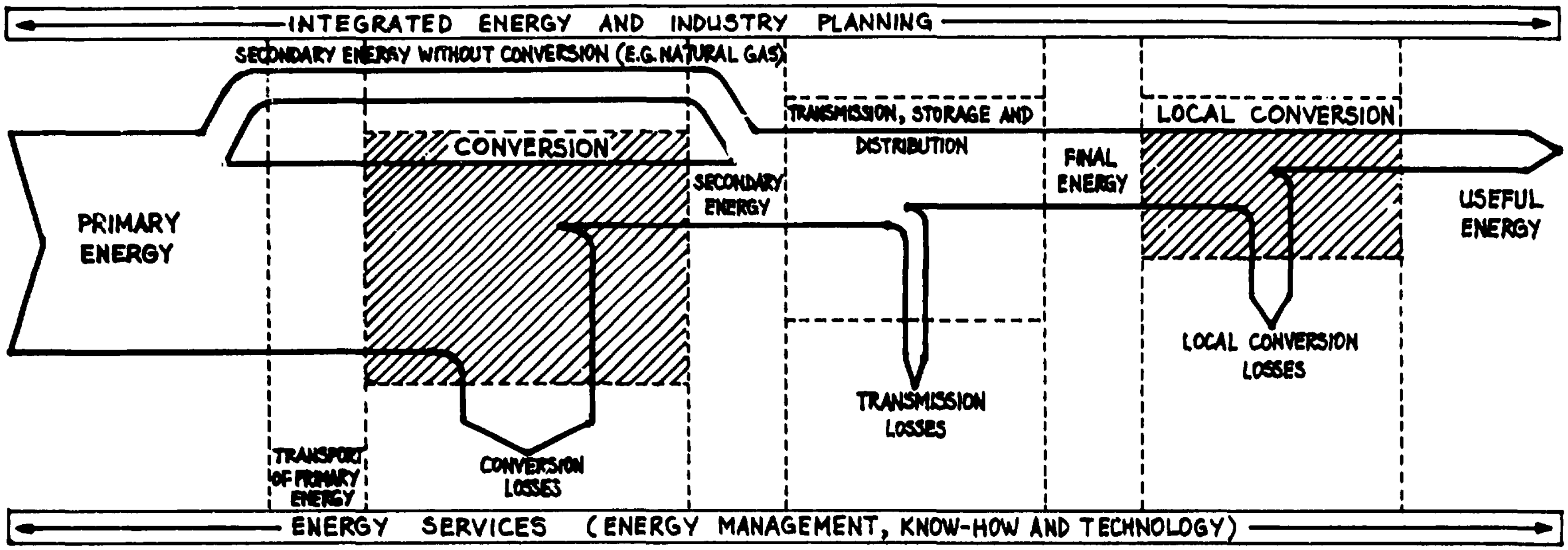
1/ UNIDO; Report of the First Consultation on the Capital Goods Industry, UNIDO/ID/276, 1981.

2/ UNIDO; Report of the IDB on its seventeenth session, UNIDO/ID/B/308, 1983.

3/ See: Issue paper I and its background document prepared for this Second Consultation: Conditions of entry into the capital goods sector and strategies for integrated manufacture.

4/ UNIDO; Report of the December 1983 meeting, UNIDO/PC.87, 5 January 1984.

Figure 1.1 Energy-related technologies and equipment



OPERATIONS:

OIL EXPLORATION, COAL (AND OTHER MINERAL FUEL) MINING, CIVIL WORKS FOR DAMS, ENERGY FARMING, ETC.	SEA AND LAND TRANSPORT OF LIQUID GAS AND SOLID FUELS	ELECTRICITY GENERATION, MINERAL AND FOSSIL FUEL PROCESSING, BIO-MASS GENERATION AND PROCESSING; WIND, SOLAR, ETC. ENERGY GENERATION; CIVIL WORKS AND STRUCTURES.	TRANSMISSION AND DISTRIBUTION OF ELECTRICITY; TRANSPORT AND DISTRIBUTION OF ALL PROCESSED FUELS, ETC.	UTILIZATION OF ENERGY IN INDUSTRY, AGRICULTURE, TRANSPORT, HOUSEHOLD SECTORS, ETC.

CAPITAL GOODS:

EQUIPMENT FOR DAMS, MINING EQUIPMENT FOR FOSSIL AND MINERAL FUELS, FORRESTRY AND AGRICULTURAL EQUIPMENT, GEOTHERMAL ENERGY EQUIPMENT.	INFRASTRUCTURE AND TRANSPORT EQUIPMENT.	EQUIPMENT FOR ELECTRICITY GENERATION (CONVENTIONAL THERMO, HYDRO, GEOTHERMAL, NUCLEAR), PROCESSING EQUIPMENT FOR MINERAL AND FOSSIL FUELS, BIO-MASS PROCESSING EQUIPMENT (BIO-GAS, CHARCOAL, ALCHOAL, COAL LIQUIDIFICATION, ETC.), WIND, SOLAR, ETC. ENERGY EQUIPMENT.	TRANSMISSION AND DISTRIBUTION EQUIPMENT FOR ELECTRICAL ENERGY, TRANSPORT AND DISTRIBUTION EQUIPMENT FOR OTHER ENERGY FORMS.	ELECTRIC MOTORS, INTERNAL COMBUSTION ENGINES, RESISTIVE ELECTRIC LOADS, HEATING SYSTEMS, INDUSTRIAL PROCESSES, ETC.

a) A typology of developing countries has been developed 5/;

b) Eleven country case studies were carried-out for UNIDO by experts from the following countries 6/:

1. Algeria	5. Egypt	9. Pakistan
2. Bolivia	6. India	10. Republic of Korea
3. Cameroon	7. Indonesia	11. Tanzania
4. Colombia	8. Mexico	

c) A synthesis of the country case studies has been made 7/;

d) A questionnaire for the survey of major equipment manufacturers has been prepared and a test run has been made among French manufacturers 8/;

e) Sets of strategies aimed at the development of electric power equipment sector have been formulated separately for each of the groups of developing countries as identified in the typology study 9/;

5. The outcome of these activities were discussed at an expert group meeting which took place in November 1984 10/. That Meeting endorsed the documentation prepared by the UNIDO secretariat and made recommendations with regard to the issues which could be considered by the Second Consultation.

1.2 Electric power industry in developing countries

6. The electric power system involving the infrastructure, equipment and services for the generation, transmission and distribution of electricity is one of the most important contributors to the industrialization and overall growth of a developing country. By the electrification of a country it is

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5/ UNIDO; Electric power equipment production in developing countries: A typology and elements of strategy, UNIDO/IS.509, 18 January 1985.

6/ The case studies are available upon request from the UNIDO Secretariat in original languages and in draft English translation wherever applicable.

7/ UNIDO; Electric power equipment production in developing countries: Options and strategies - An analysis of eleven country case studies, UNIDO/IS.507 and Add 1, 7 January 1985.

8/ Documents available upon request:
a) Analysis of the strategies of actors involved in the electric power equipment industry: problems and survey questionnaire for manufacturers.
b) Survey on French companies producing electric power equipment

9/ Op. cit. 5/

10/ UNIDO; Report of the Expert Group Meeting on the Electric Power Equipment Industry, UNIDO/PC.107, 11 December 1984.

possible to create at one and the same time favourable conditions for industrial development and the improvement of the population's living conditions. Moreover, rural electrification is a fundamental element in all programmes to improve the living conditions of rural population, thus in turn contributing to the efforts being made by all developing countries to halt the rural exodus. It also makes possible to encourage the emergence of small-scale industries and their better distribution throughout the country. Therefore, all developing countries give high priority to electrification programmes, including, more and more, rural electrification.

7. Since investments in electricity generation have priority in most developing countries[11/], electric power equipment is in great demand in these countries. Although the shares of developing countries in the world installed capacity and generation of electricity are small (in 1982, 16.01% and 15.86%, respectively), their corresponding growth rates have been greater than those of developed countries (see Annex I). During the 70's the rate of growth of installed capacity[12/] in developing countries was 9.2% compared to 5.5% in developed countries. These growth rates, however, have substantially slowed down in the 80's: For example, between 1980 and 1982, to 6.6% and 3.1% in the developing and developed countries, respectively.

8. Typically, for most developing countries, the ratio of growth rates of electricity generation to GDP, averaging around 1.2, is higher than that of growth rates of energy to GDP, averaging around 1.0. This is even more evident after 1973, when the share of oil in total energy began to fall due to the rise in oil prices. The reasons for this are not difficult to find. As seen from Figure 1.2, on the supply side, electricity is a flexible form of

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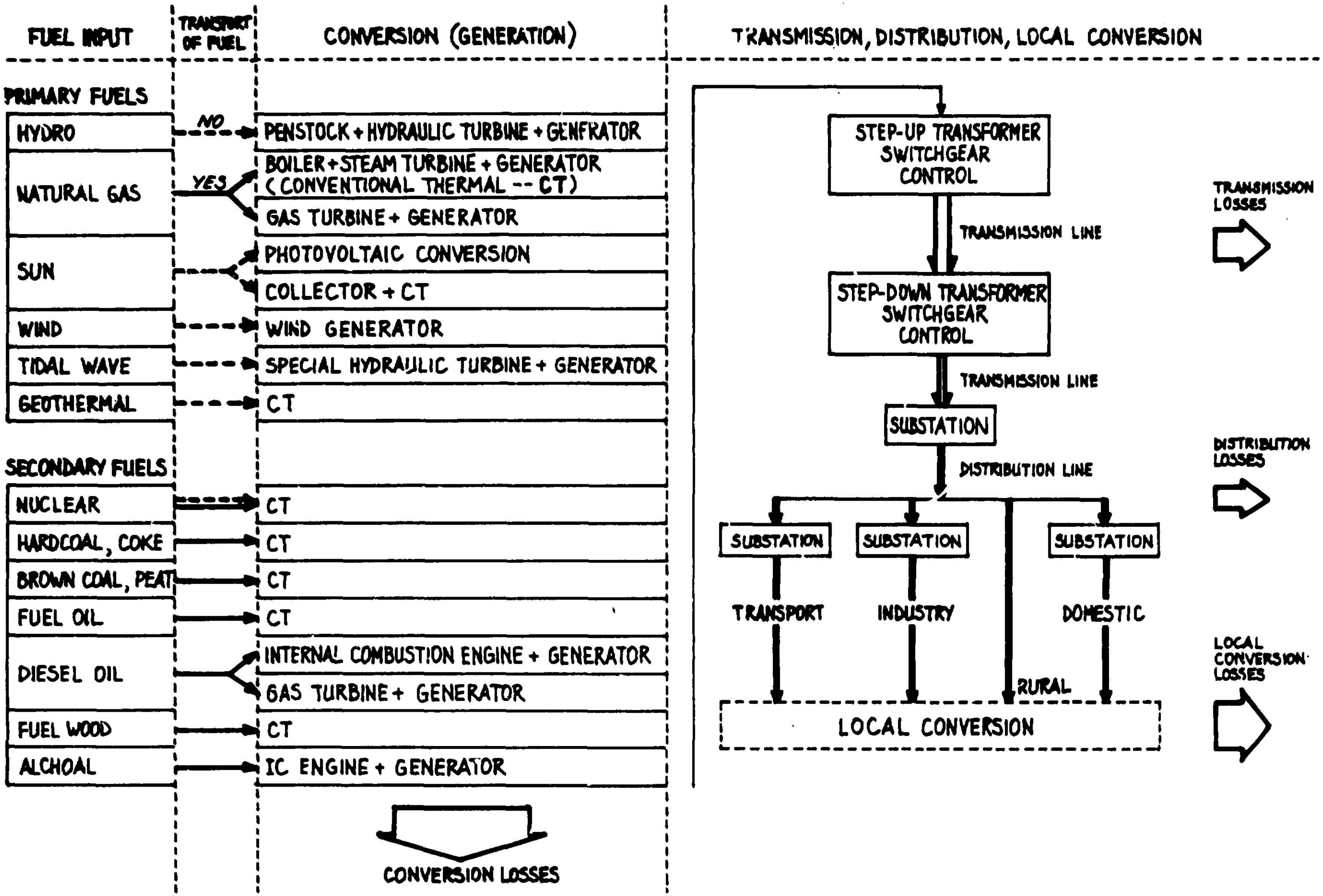
11/ The power sector claims one of the largest shares (18 to 20%) of public investment in most developing countries. It also claims the largest component of aid provided to developing countries.
   a) UNIDO; Investment requirements of developing power industries for the industrialization of developing countries, UNIDO/IS.359, 1982.
   b) Collier, H.; Developing electric power: Thirty years of World Bank experience, The World Bank, 1984.

12/ As an indicative parameter, installed capacity is preferred over electricity generation and/or consumption since it relates directly to the market for electric power equipment.

Figure 1.2 Electricity: Generation, transmission, distribution and final conversion



energy that could be generated from several indigenous sources, e.g. hydro, coal, gas, fuel-oil, nuclear, geothermal, etc. On the demand side, it is a highly efficient and versatile form of energy that could be used in thermal and electro-chemical processes, and through electromagnetic conversion for rotating. In the developing countries, it is increasingly becoming a substitute for human energy, non-commercial energy and energy from fossil fuels --especially oil. Thus, in spite of the high oil prices, electricity growth rates have continued to be high, although not as high as they used to be prior to 1973.

1.3 Procurement of electric power equipment by developing countries

9. The developing countries imported electric power equipment of nearly US$ 15 billion (in current dollars) in 1983. For the individual countries, such imports represent a large share of export earnings. Among the total imports of energy-related capital goods, the electric power sector claims on the average a share of nearly 75%, the remaining share being mainly for equipment related to fossil fuel development. The share of electric power equipment is even higher for those countries which do not have fossil fuel resources.

10. The procurement of electric power equipment by developing countries does not concern them alone but also the developed countries. Of the total world trade of about US$ 45 billion, the share of developing countries was nearly 32% in 1983. Their share in the world trade rose from 27% in 1970 to nearly 34% in 1980[13/].

11. It is interesting to note that, in most developing countries, the new electricity generation capacities have been created through turn-key supply

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13/ While this trend of rising shares was interrupted in 1983, the informal inquiries with manufacturers from developed countries indicate that during the remaining years of the decade, a considerable part of the business is expected from the developing countries --see: Op. cit. 8(a) and (b)/.

arrangements[14,15,16,17]. These arrangements, which impact negatively on the development of an indigenous industry have possibly been made as a result o_:

- Policies of packaging of large power generation and transmission projects of high technological complexity, effectively excluding local participation;
- Policies by funding agencies that are actively prejudice against all but established firms;
- De facto actions on the part of, for instance, electric power utility decision makers in the developing countries who may believe that for the reasons of product quality, reliability or consistency or simply from habit that equipment must be purchased from a foreign supplier.

12. In order to reduce the payments in foreign exchange and to increase one's self-reliance, the developing countries have to mobilize their efforts for domestic manufacturing of electric power equipment in whatever modest a way possible. Behind the goals of indigenization lies the basic desire for participation in the process of industrialization. Whether small or big, whether oil exporting countries or islands and land-locked countries, they all recognize the need for industrialization, although patterns of industrialization may differ for each. Electricity is an essential component for this industrialization; however, the specific priority for manufacturing electric equipment would depend on the extent of electricity demand, patterns of industrialization, priorities of other sectors which may alsoclaim skilled personnel and financial resources, etc.

1.4 Scope of the study

13. A schematic diagram of an electric power system is given in Figure 1.3. The establishment and operation of such a system include both the hardware activities such as manufacture and assembly of all related equipment,

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14/ Op. cit. 5/.
15/ Op. cit. 7/.
16/ UNCTAD; Technological impact of the public procurement policy: The experience of the power plant sector in the Republic of Korea, UNCTAD, TD/B/C.6/105, 1984.
17/ UNCTAD; Trends in the procurement of electricy generating plant in developing countries, UNCTAD, TD/B/C.6/AC.9/3, 1982.

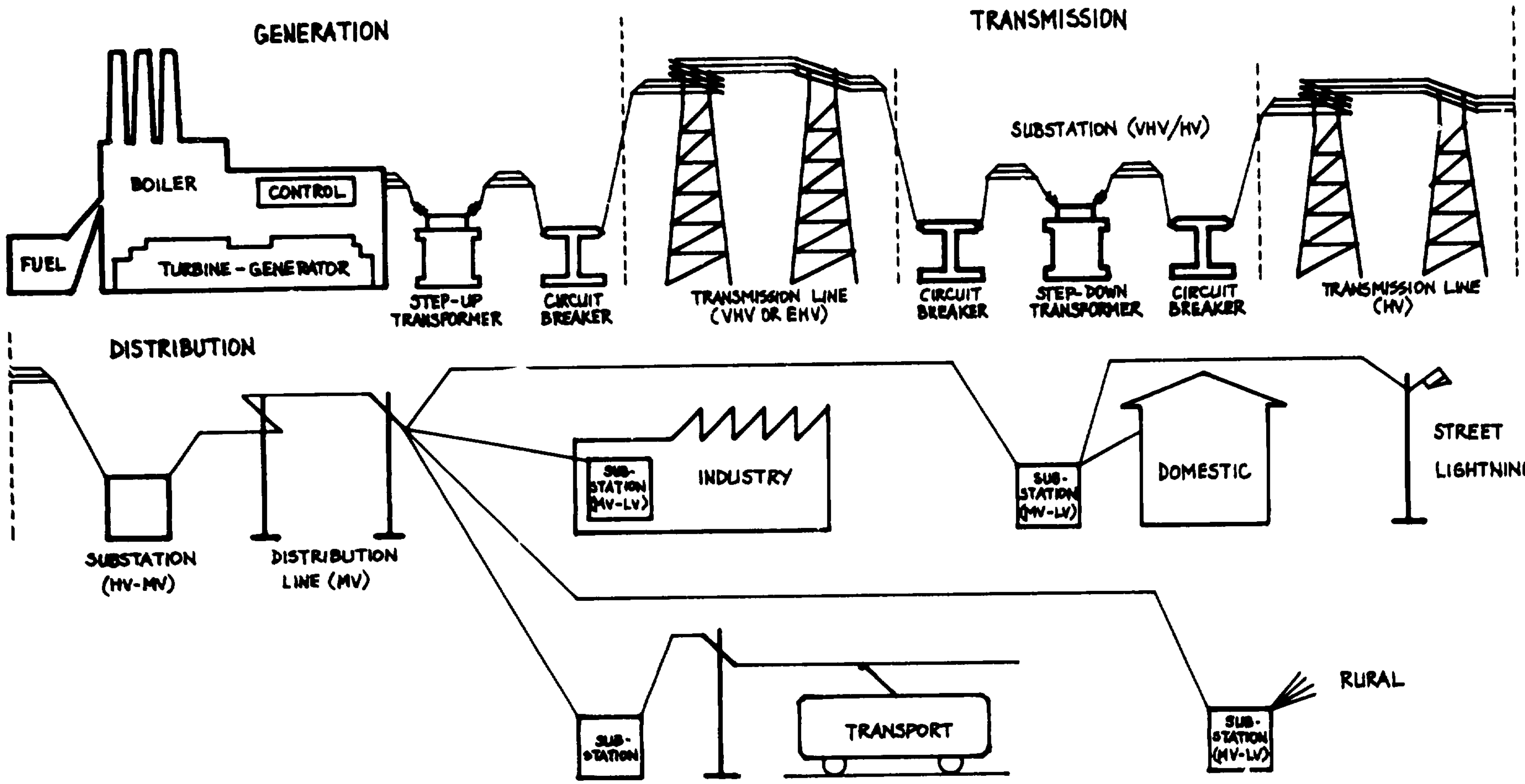

Figure 1.3 Schematic diagram of an electric power system.

construction of dams, structures and buildings, and software services such as planning, consultancy and engineering, supervision, research and development, etc. for the generation, transmission and distribution of electrical energy. These equipment and services cover a wide spectrum of varying complexity levels from the simple wooden distribution pole to the very complex gas turbine; and from simple civil engineering for rural electrification to very complex large power plant engineering.

14. In order to be able to describe the process of development of the electric power sector, one must take into consideration all the activities and products mentioned above. The wide scope of these activities and products makes it possible for developing countries to enter into the electric power sector at a complexity level which is compatible with their development stage. The main purpose of this approach is, therefore, not to limit targets merely to the production of capital goods, and consequently, not to exclude a large number of countries from the scope of discussion. In practice, furthermore, equipment in the strict sense represents on the average only 50% of investments (for a medium voltage distribution line, for example, the share of equipment is even lower).

15. While the purpose of this paper is to focus on the manufacturing of electric power equipment, the discussion on the electric power systems and power projects is inevitable. The former is not concerned with isolated components to be manufactured or imported, but a whole system --including construction, installation, operation and repair and maintenance. This again splits into power generation, transmission and distribution systems. The latter is extremely important for the developing countries in view of the much needed rural electrification, which involves considerable on-site labour and low-technology components. These could be manufactured in the developing countries[18/]. On the other hand, electric power projects include the entire process from project design, feasibility studies, construction, supply of equipment, assembling, testing, quality control, etc. Thus, power projects include much of the on-site activities which are not directly concerned with manufacturing but within the capability of many developing countries.

18/ Op. cit. 3/.

16. In an effort to identify the possibilities for developing countries to increase their participation in the development of their electric power systems in general, and implementation of specific electric power projects in particular, an approach which may be called **"technology unpackaging"** is adopted here. The technology package is defined as the combination of all the hardware and software activities involved in the establishment and operation of electric power systems and/or projects. Technology unpackaging, however, is defined here as the capability of disaggregating a power system project into its component activities and progressive mastery and/or indigenization of each activity.

CHAPTER 2

INTEGRATED PLANNING FOR ELECTRIC POWER EQUIPMENT: NATIONAL OBJECTIVES AND ECONOMIC PLANNING

2.1 Introduction

17. As illustrated in Figure 2.1, it is essential that integrated planning should be done for electric power equipment so as to be in harmony with the national objectives, economic planning and development of other sectors --and some specific sub-sectors-- of the economy.

18. In setting the national objectives, the availability of natural, resources, human and physical capital, geoclimatological and demographic conditions as well as cultural and traditional aspects need to be considered in order to be able to maximize the advantages and to minimize the risks. These national objectives and rationale behind them would have to be considered for economic planning. For example, some countries, whose primary goal is to meet the basic needs of their population, may emphasize food production: Therefore, substantial shares of energy and electricity would be required for irrigation, food processing, households, etc. On the other hand, some newly industrializing countries (NICs) may need different types of industries and rather advanced service sector, and therefore, their energy and electricity requirements would be different. Thus, economic planning would lay down the ground rules of the interrelationships between the development of several sectors. The concern of the present paper is restricted to the integrated planning of industry and energy[19,20/], and the linkages between industry, energy and electricity.

19. Figure 2.1 illustrates this hierarchy and the industry-energy-electricity nexus within the rest of the economy which needs to be considered before assigning priorities to the manufacturing of electric power equipment. Referring to Figure 2.1, first, the sectors (boxes) and then the linkages (arrows) between sectors and sub-sectors related to the industry-energy-electricity nexus are discussed.

19/ UNIDO; Energy and industrialization, with special emphasis on development and application of energy resources and manufacture of equipment, Fourth General Conference of UNIDO, ID/CONF.5/7, 1984.

20/ UNIDO; Energy development and industrialization, UNIDO/OED.135, 1982.

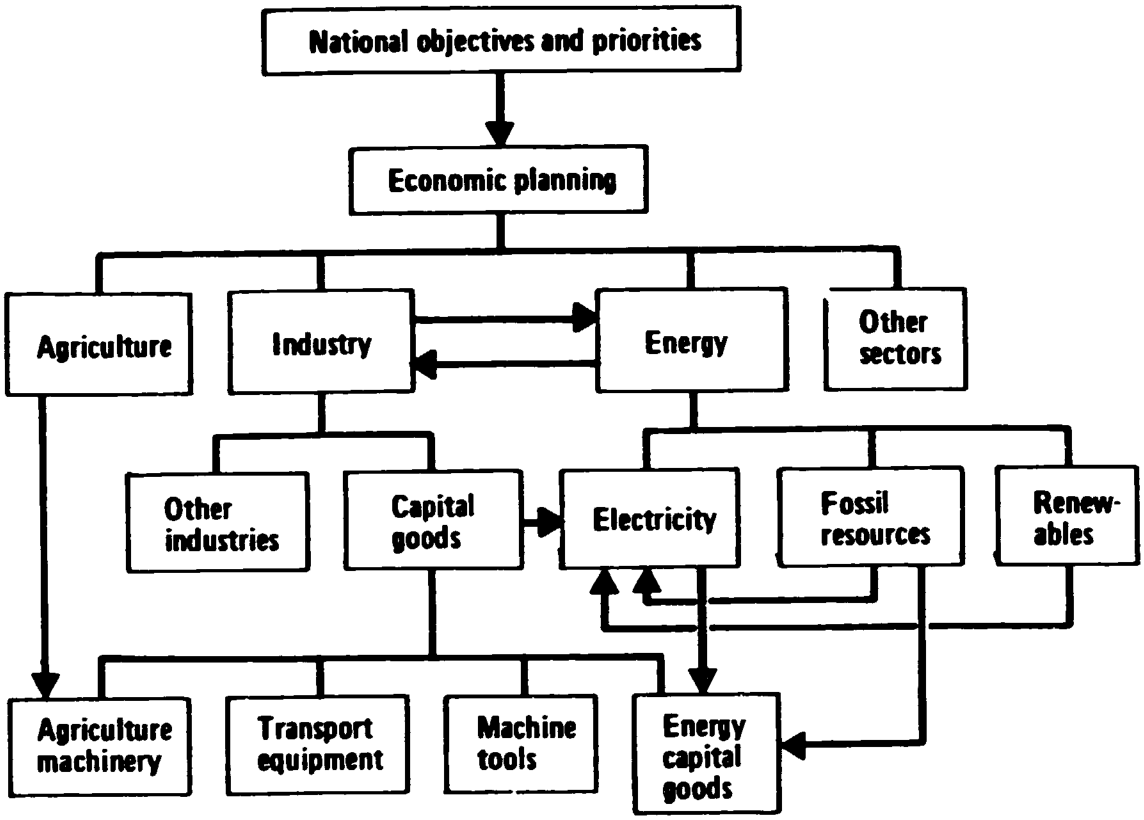

Figure 2.1 Interdependence of sectors indicating the need for integrated planning

2.2 Integrated energy and industry planning

20. Long-term energy planning is a prerequisite for identifying actual projects for energy development as well as planning for manufacturing electric power equipment. Energy planners should consider, with other elements, the future demand for energy for the rising population and income, the availability of mineral and renewable energy resources, the need for and the viability of fuel-substitution through electricity.

21. Long-term industry planning would require to consider, among others, the skills pool, mineral resources, supply of intermediate goods, technical infrastructure and available financial resources. In general, industries based on primary resources, such as textiles, paper, cement, iron and steel, etc., and import substituting industries manufacturing consumer durable goods, have received greater attention in the developing countries than the capital goods industry which requires higher levels of infrastructure, skills, capital as well as an assured continuous demand. Furthermore, within the capital goods sector, there are a number of subsectors among which the priorities would have to be assigned. Some examples are agricultural machinery, machine tools, transport equipment, energy-related capital goods, etc. industries[21/].

2.3 Energy for industry

22. In the developing countries, the industry is often the largest user of commercial energy. If non-commercial energy is included, however, in many of the low-income developing countries the household sector turns out to be the largest user. Among various energy forms used in the industry, electricity has a special role. There are very few industries which do not need electricity. Industries could be classified in three categories for the purpose of energy planning (which is a somewhat different composition than that illustrated in Figure 2.1):

a) High energy-consuming industries such as iron and steel, non-ferrous metals, fertilizers, heavy machine building, etc. are often called

21/ Op. cit. 3/.

heavy industries. One could also add paper, cement and textiles as moderate energy users to this category, even though per ton of output they do not require as much energy as the heavy industries. Because of the relatively high demand for these basic products, significant share of the total energy used in the industry as a whole is allocated to these industries.

b) Other industries which require small or moderate amounts of energy, such as manufacture of light machinery, chemicals, rubber, pottery, etc.

c) Rural industries (such as manufacture of bricks, lime, charcoal, simple chemicals --soaps, dyes, etc.; leather processing --tanneries; food processing industries --rice mills, flour mills, oil mills, sugar mills, and fish, meat, vegetable and fruit processing and preservation; etc.) require a different approach to energy and call for rural electrification and development of locally available new and renewable energy sources (NRSE) such as bio-gas generation, solar and wind energy, small-scale hydropower generation, etc.

2.4 Industry for energy

23. This linkage is the most important for the present discussion. Each of the categories of industries described above has a role to play in the energy supply development and, therefore, in making more energy available to industries. For example, industries in category (a) provide the basic raw materials required for manufacturing capital goods for energy; i.e. iron and steel, aluminium, cement, etc., which in turn require energy. In fact, there is a high correlation between the extent of energy-intensive material production, such as steel, aluminium, etc. in a country and the extent of self-reliance in the manufacture of capital goods for energy.

24. The light to medium-sized energy-related equipment, such as motors, distribution transformers, water pumps, pipes, valves, cables, etc., which require the infrastructure of industries mentioned in category (b) and are generally manufactured by these industries.

25. There would be also an input from the rural industries in terms of the energy-related capital goods and energy facilities. Manufacture of bricks for civil works, wooden poles, bio-gas generators; repair and maintenance of and supply of other skills for the rural electrification installations are examples of such an input.

26. Thus, industry and energy are interdependent and energy or electricity development calls for integrated industrial planning with energy and electricity components built into it. Going one step further, even the development of the electric power equipment industry is a step process that goes hand in hand with the industrial development and industrial infrastructure.

27. After illustrating the interdependence between the sectors and subsectors, next the question of manufacture of electric power equipment will be discussed.

CHAPTER 3

MANUFACTURE OF ELECTRIC POWER EQUIPMENT AND CLASSIFICATION OF EQUIPMENT AND DEVELOPING COUNTRIES

3.1 Introduction

28. When one considers an issue that covers a large number of types and sizes of equipment, widely varying services and more than 100 countries, a conceptual framework for aggregation and grouping is necessary. Without this, it may be difficult to identify the problem and to formulate the possible policies and strategies. This section develops classification principles of technologies for different equipment and a country grouping methodology.

3.2 Classification of equipment

29. For classification of capital goods, UNIDO has developed the methodology of Analysis of Technological Complexity (ATC)[22/]. ATC enables the grouping of all capital goods according to their technological production routes and six complexity levels. These six levels are determined by a complexity index which takes into account all software and hardware factors of product and production. A comprehensive analysis and classification of electric power equipment using ATC has not yet completed. Therefore, a simpler grouping based on few indicators is adopted here[23/].

30. The indicators used for classification here are:

a) **Size and scale of the item:** This factor is crucial for manufacturing certain items, such as 5 MW or 500 MW turbo-generators, or 33 kV or 400 kV transmission lines. The lower-end equipment may be easier to manufacture than the latter. Furthermore, the required size of manufacturing facilities and the level of technical infrastructure are generally determined by this factor.

b) **Precision and skills required for manufacturing:** The manufacture of some equipment, independent of size, may require high precision and

22/ Op. cit. 3/.
23/ Op. cit. 7/.

specific skills. Large turbo-generators and computerized measuring and controlling equipment are examples from extremities of the size scale.

c) **Demand for the item:** If a large number of units are required every year, mainly due to domestic demand but also partially due to the possibility of exports, manufacture of these equipment becomes economically viable, e.g. distribution transformers, poles, wire, cable, etc.

31. The electric power equipment industry is not a prime-mover of and/or an entry route into the capital goods sector. On the contrary, its development is depended upon the existing level of capital goods industry, engineering skills and supply of intermediate goods. For all countries, therefore, there is the question of linkage between the electric power equipment sector and the capital goods sector as a whole. Keeping this in mind, it is reasonable, however, to assume that decision-making for domestic manufacturing versus imports would have to balance the above three indicators.

32. Based on these indicators, the following broad classification pattern can be suggested for electric power equipment[24/]:

a) **High technology equipment:** These are often large-size equipment which may require sophisticated skills and precision in manufacturing. Generally, they are not needed in large numbers and therefore there are only a few manufacturers; often only one in a country, if any. They include large items like turbines, generators, boilers, high-power and/or high-voltage transformers; precision items such as measuring and controlling equipment, etc. They relate in particular to large-scale power generation and high-voltage transmission. Often they are tailor-made for specific locations and conditions which may be difficult.

b) **Medium technology equipment:** Distribution transformers, switchgear, small- and medium-sized motors, compressors, pumps, etc. are considered medium technology items. They are demanded in large numbers and could often be manufactured by several manufacturers. They do require precision and skills but not of especially high order. Some are also used by industries other than the energy, leading to increase in demand.

24/ Institut de Recherche Economique et de Planification du Developpement, Gronoble, France (UNIDO Consultants); Capital goods for the production and distribution of electrical energy, 1979.

c) **Low technology equipment:** These refer to items like metal transmission towers, wire and cable, fuses, etc., which are usually required in large quantities. They have great relevance in rural electrification, and some of them could also be manufactured in the unorganized sector.

33. The activities in connection with the establishment and operation of the electric power system are not limited to manufacture of equipment but also include a variety of software services. These services, as in the case of equipment, could be classified according to their complexity: Low complexity services such as simple civil engineering, design and development of rural distribution systems, assembly of moderate-size power plant equipment, etc.; medium complexity services such as design and development of power plant projects, specifying equipment, supervision of projects, engineering of low and medium voltage transmission and distribution systems, etc.; and high complexity services such as design and development of equipment, operation and management of the system, etc. Another indispensable activity which may assume any complexity level is the repair and maintenance.

3.3 Grouping of developing countries[25/]

34. Owing to the unequal level of development of developing countries, it is not possible to deal with all of them in an undifferentiated manner. In some of the countries there is no capital goods industry, so that it will be necessary to consider a strategy for commencing activity in this branch. In the other extreme, the national capital goods industry produces the full range of equipment; then it will be a question of consolidating this industry and of enabling it to produce the most sophisticated types of equipment and/or give it access to advanced technology. Similar differences also exist between the software capabilities of different developing countries. Between these two extremes, one can find almost all levels of the development of this industry. It is beyond the scope of this paper to deal with every country individually. Therefore, the countries are grouped according to their potential to develop the electric power equipment industry.

25/ - Op. cit. 5/.
- Op. cit. 3/.
- Op. cit. 11(a)/.

35. At the world level, the electric power industry is often represented as an oligopoly, as a cartel 26,27,28,29,30,31,32,33,34/. This statement can be softened in the case of more ordinary equipment, for which the technology has been mastered in a large number of medium-sized companies in the industrialized countries and in a growing number of developing countries. In this case, the respective bargaining capacities of the owner of technology and the developing country desirous of obtaining it are very different from that in the first case. The grouping of developing countries will therefore also make it possible to take into account this gradation in bargaining conditions for the transfer of technology.

36. The final typology should, therefore, permit the formulation of strategies

- that take into account the differences in the industrialization level of the countries;
- that are linked to the technological complexity of the hardware and software activities whose indigenization is envisaged; and
- that evaluate bargaining power for the transfer of technology according to the structure of the electric power equipment industry at world level.

26/ Op. cit. 8/.
27/ UNCTAD; Impact on developing countries of restrictive business practices of TNCs in the electrical equipment industry: a case study of Brazil, UNCTAD, ST/MD/9, 1978.
28/ UNCTAD; The international market power of TNCs: A case study of the electrical industry, UNCTAD/ST/MD/13, 1978.
29/ UNCTC; Transnational corporations in the power equipment industry, UNCTC, ST/CTC/22, 1982.
30/ Epstein, B.; Politics of trade in power plant, Trade Policy Research Centre, London, 1971.
31/ Epstein, B. and Mirow, K.R.U.; Impact on developing countries of restrictive business practices of TNCs in the electrical equipment industry: A case study of Brazil, UNCTAD/ST/MD/9, 1978.
32/ Newfarmer, R.; Translational conglomerates and the economics of development: A case study of the international electrical oligopoly and Brazil's electrical industry, Jai Press, Greenwich, Connecticut, 1980.
33/ Sultan, R.G.M.; Pricing in the electrical oligopoly, Vol. I: Competition or collusion, Harvard University Press, Cambridge, Massachusetts, 1974.
34/ Surrey, A.J.; World market for electric power equipment, Science Policy Research Unit, University of Sussex, 1972.

37. A typology prepared along these lines is presented in another document prepared for this Second Consultation[35/]. For the purpose of this paper, however, a simplified version of that typology was developed. The simplification is achieved by applying another indicator, i.e., the total installed electricity generation capacity and its average annual growth rate. The reclassified groups are shown in Table 3.1.

38. Referring to Table 3.1, the following is a brief description of the main characteristics of the country groups:

a) **Group A (Newly Industrializing Countries - NICs):** In 1982, this group had nearly 60 per cer' of the total installed electricity generation capacity of developing countries. It consists of seven countries presently engaged in manufacturing electric power equipment requiring skills and facilities of somewhat large-scale nature. Their attributes, except Singapore (which is included in this group because of its high production capacity and large market), are:

   - Annual energy consumption of at least 30 million tons of oil equivalent (30 mtoe);
   - Total installed electricity generation capacity is more than 10,000 MW;
   - Annual increments in the electricity generation capacity in the order of the multiples of 1,000 MW;
   - Large domestic markets for electric power equipment.

b) Group B: This group includes nearly thirty countries which are or could be engaged in manufacturing low- and medium-technology items. During the period 1970-1980, most of these countries added generation capacity of 2500 MW and more. Their total installed generation capacity is between 1,000 and 10,000 MW This group had nearly 30 per cent of the total electric capacity of the developing countries in 1982.

c) Group C: This group consists of numerous small countries (more than 80) which have very limited manufacturing capacity even for the low technology items. Some countries of this group, such as the least developed countries (LDCs), may even find it difficult to maintain their power systems due to lack of spare parts and skilled personnel. They may require assistance, financial as well as technical for power system planning. Their annual demand is within the range of 1 MW to 50 MW. Most of the countries of this category added less than 250 MW during the decade 1970-1970. Except a very few cases, their installed generation capacity is below 1,000 MW.

35/ Op. cit. 5/.

39. The above discussion makes it clear that the policy for manufacturing or importing the electric power equipment would depend on the country characteristics and the level of technology required for manufacturing. There is also the question of modalities for manufacturing which is discussed in the next chapter.

Table 3.1 Typology of developing countries

GROUP C	GROUP B	GROUP A
1 Afghanistan	1 Algeria	1 Argentina
2 Angola	2 Bangladesh	2 Brazil
3 Bolivia	3 Burma	3 China
4 Burkina Faso	4 Chile	4 India
5 Cameroon	5 Colombia	5 Korea, R of
6 Central African Republic	6 Cuba	6 Mexico
7 Chad	7 Ecuador	7 Singapore
8 Congo	8 Egypt	
9 Costa Rica	9 Ethiopia	
10 Dominican Republic	10 Ghana	
11 El Salvador	11 Indonesia	
12 Guatemala	12 Iran, Islamic Republic	
13 Guinea	13 Iraq	
14 Haiti	14 Ivory Coast	
15 Honduras	15 Kenya	
16 Jamaica	16 Korea, Dem. People's Rep.	
17 Jordan	17 Malaysia	
18 Kuwait	18 Morocco	
19 Lebanon	19 Nigeria	
20 Liberia	20 Pakistan	
21 Libyan Arab Jamahiriya	21 Peru	
22 Madagascar	22 Philippines	
23 Malawi	23 Saudi Arabia	
24 Mali	24 Sri Lanka	
25 Mauritania	25 Syrian Arab Republic	
26 Mozambique	26 Thailand	
27 Nepal	27 Tunisia	
28 Nicaragua	28 Venezuela	
29 Panama	29 Zaire	
30 Paraguay		
31 Senegal		
32 Sierra Leone		
33 Somalia		
34 Sudan		
35 Tanzania, United Rep.		
36 Togo		
37 Trinidad and Tobago		
38 Uganda		
39 Uruguay		
40 Yemen		

CHAPTER 4

MODALITIES: EVOLUTION FROM IMPORTS TO INDIGENIZATION

4.1 Introduction

40. The analysis of eleven country case studies carried out for UNIDO[36/] and additional country information[37,38,39/] have shown that there is a gradual transformation in a country's ability to manufacture simple low technology items, such as poles, pylons, wires and cables, etc. to high technology items, such as generators and turbines. This depends on the needs of the country and other parameters which are identified while classifying the countries into groups A, B and C. There is yet another variable to this transformation and that concerns modalities. From a complete import of turn-key project mode, a country could gradually strengthen its capacity to indigenize to the extent possible by going through one or more different modes. These alternative modes may or may not be completely gradual depending on the policies pursued; but while a few steps could be jumped, it is unlikely that a country would switch from total import reliance to complete indigenization without going through intermediate modes whereby they go through a learning process so as to master technologies, develop skills and infrastructure. Relative advantages, constraints and prerequisites for these modes are discussed below. The order of these modes, however, may vary depending on the specific approach of individual countries.

41. Recalling the distinction made in para. 15 concerning power systems and power projects, it is appropriate here to mention the distinction between unpackaging projects and unpackaging technology. The former involves carrying out the planning and design, feasibility studies, choosing parameters and specifications of different components, assembling and installing hardware,

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36/ - Op. cit. 6/.
   - Op. cit. 7/.

37/ Electric power equipment industry in Sri Lanka, in op. cit. 7/.

38/ Production of equipment for power generation and distribution in Peru, in Industrial restructuring in Peru - Policies for growth and development, UNIDO, (to be published).

39/ The viability of establishing a regional electric power equipment industry in the ECWA Region, UNECOSOC/ECWA, E/ECWA/ID/WG.4/6, 1980.

on-site construction etc. Some of these activities can be carried out gradually by a team of skilled and trained personnel without entering the phase of manufacturing. On the other hand, unpackaging technology refers to understanding the design and technological manufacturing route of individual components and actually manufacturing them, including the testing and quality control. Thus, the first three modes mentioned below deal with unpackaging projects while the next four modes refer to manufacturing the equipment. It should also be stressed that the modalities described below do not necessarily apply to electric power generating systems alone but also to power transmission and distribution.

4.2 Modalities of indigenization

42. **Turn-key import from a single source:** This mode is pursued by many developing countries of groups B and C. It is often delivered with speed and reliability and by a single source, which takes the full responsibility of its execution, but puts on a high premium for risk factors such as possible charges that may arise due to failure of any component and/or sub-contractor. Therefore, it involves significant foreign exchange and due to this requirement, the international funding agencies can have a great influence on such projects. The responsible firm (prime contractor) subcontracts other firms of their own choice and takes the responsibility to match the specifications of different components and to exercise quality control. Apart from paying high costs, a developing country may not always get what is in its best interest. Furthermore, in this mode, there is no scope for national participation since all the responsibilities and control are given to others.

43. **Assembling imported parts:** This may be a yet cheaper way of constructing a power plant, in which all the components are imported but assembled within the responsibility of local parties. The local participation would also involve planing and construction of the civil works, and taking the responsibility of making the equipment function. This mode could be adopted especially in the cases of hydro-power generation plants and the transmission and distribution systems. Entirely different meaning of this mode, namely, an assembly line for mass producing a particular item, is excluded here.

44. **Assembling from different sources:** This mode requires a competent team of skilled technical personnel who know what is involved in ordering a power plant and could specify and match the different components. Adopting this mode may make it possible to obtain better bargains. However, the responsibility of exercising quality control, risk of failure of each component, etc. will be with the team that orders the equipment. As and when components from domestic firms are substituted for imported ones, this mode could promote the indigenization of power system components.

45. **Foreign subsidiaries:** As and when the domestic level of skills and the strength of infrastructure increases, and provided that the market size satisfies certain criteria, foreign firms may get interested in setting up subsidiaries by bringing capital and technology into a developing country. They do not, in general, part with the technology but there are many peripheral activities in which domestic skills may develop. This provides employment and work-environment for skilled and semi-skilled labour. Moreover, the equipment made by them will, in all likelihood, meet domestic performance requirements because the firms will be first interested in capturing markets of the developing countries they operate. However, the development of this mode depends upon the economic policies of the host country and offers of attractive benefits for encouraging such ventures and the rights of the subsidiaries to repatriate their profits.

46. **Domestic manufacturing under licence:** As and when the technological infrastructure gets stronger and domestic market expands, and provided that clear Government policies and incentives exist, the domestic firms get interested in manufacturing equipment themselves --either under licence or adopting the designs of those equipment which have expired patents. Some low- and medium-technology items could be directly manufactured under this mode for import substitution. However, for more complex items, this mode could be difficult and costly. In general, this route involves modifications in the design of products and processes to adopt them to local conditions. The critical success factor of this mode is to aim at mastery of technologies and higher local participation, rather than to choose the easy way and stall at the assembly phase.

47. **Joint ventures:** When the technological level and the market size in a developing country meet their requirements, the foreign firms may be interested in taking domestic firms as partners for which equity is shared and so are the responsibilities. Here again, certain Government policies may be necessary such as the contractual terms concerning technology transfer.

48. **Complete indigenization:** This involves total disengagement with any foreign firms. This is, of course, not very difficult for low and medium technology items but for more complex equipment, complete mastery of technology, local R+D, design and innovation capability, etc. are required, as well as the existence of a developed infrastructure. This is the final step of evolution process and is complete only when the developing countries begin to become economically competitive with the developed countries in manufacturing a given equipment of similar quality

4.3 Role of Government policies: Some examples for different modes

49. Each one of the modes discussed above has its advantages and disadvantages. Their applicability in a specific case of a developing country would depend not only on the economic and technological factors, but also on the policies and strategies adopted by that country. Furthermore, the parties involved in each case and/or mode could be different. For example, technology donor could be a Transnational Corporation (TNC) or a Small- and Medium-sized Enterprise (SME) from a developed country or a company from a NIC. The national firm engaging in manufacturing activity could be a state enterprise or a private or a mixed one. The role played by bilateral/multilateral/ international funding agencies might also be different for each case. But one important consideration which permeates all modes is that the relevant Government action, which is based on clearly stated and concretely implemented political decisions and on the leverage of the public utilities hold as the purchasers, is a prerequisite for the development of electric power equipment sector.

50. Governments of many developing countries have taken political decisions

to increase indigenization in industries in general, and in electric power equipment industries in particular. Some of these actions by the Governments of countries from Group A (NICs) are described below. Even though these experiences may only be indirectly relevant, they may help to understand implications of various policies and hindsights that are obtained so as to change policies in future or to provide guidance to other countries.

51. Brazil[40/] has promoted the rapid expansion of the sector through joint ventures with and/or through subsidiaries of the transnational corporations. Although these companies are allowed to operate freely as far as technology, patents and innovation are concerned, there are restrictions concerning financial management, such as repatriation of profits, import and export restrictions, taxes, etc. The subsidiaries normally employ Brazilians but the policy decisions are with the parent firms abroad. As a result, Brazil has access to the modern technologies and the Brazilians obtain certain type of training, i.e., create certain work environment and to operate under certain management practices and disciplines of the foreign firms. On the other hand, the foreign firms have little association with the domestic firms and since technology and patents are with the parent firms, no experience could be obtained for design and innovation. The existence of these subsidiaries force the domestic firms to be competitive because they compete for the same contracts through tenders but since the domestic firms cannot afford extensive R+D, they are at a disadvantage. Nevertheless, over the years, Brazil has developed manufacturing capabilities of high order and is reasonably diversified. Furthermore, the involvement of subsidiaries in engineering and consultancy services was reduced in time by indirect legislation promoting national firms.

52. In the Republic of Korea[41/], technology unpackaging is mainly done by

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40/ - Op. cit. 10/.
- Op. cit. 27/.
- Op. cit. 28/.
- Op. cit. 30/.
- Op. cit. 31/.

41/ - Op. cit. 6/.
- Op. cit. 7/.
- Op. cit. 10/.
- Op. cit. 16/.

using the purchasing power of the utility. The country drew up clear indigenization policies and strategies and obtained technology through licenses bought by the national enterprises wholly or partly owned by the utility. The private firms in the sector are also active, but direct involvement of foreign capital does not exist. The required inputs of production are imported freely at the beginning and indigenized progressively as they become available within the country. The utility in this country plays the central role and is involved in every aspect of the development of the sector.

53. In India[42,43/], the heavy electrical industry has been established through state enterprises and with the aim to attain complete self-sufficiency. In line with this target basic engineering capabilities has been created and technology transfer has been made through a limited number of licences. The domestic market is protected and every effort is made to indigenize the inputs required for production.

54. It could be argued that the cost of development of the electric power sector could greatly vary in each of the alternative routes mentioned above. As a future activity, the analysis of costs and risks involved in each case could be carried out to assist the decision makers in the developing countries[44/].

4.4 Aspects of indigenization

55. There are several arguments that could be made against the increased efforts by the developing countries for indigenization in the electric power

42/ - Op. cit. 6/.
- Op. cit. 7/.
- Op. cit. 10/.
- Op. cit. 28/.

43/ Krishnamurthy, V.; A case study of Bharat Heavy Electricals Limited (BHEL), in The changing role of public industrial sector in development, UNIDO/IS.386, 1983.

44/ This activity was recommended by the Expert Group Meeting on Electric Power Equipment Industry, November 1984 (report op. cit. 10/).

equipment industry. Some of them may be valid in some situations but some others not. They are discussed below to illustrate why and when they are valid and what exceptions should be made.

56. It may be difficult to justify efforts for building up a technology which is not required often or not in sufficient magnitude. This is the case for countries in Group C and some countries of group B which add less than 50 MW annually to their installed capacity. However, in these cases, indigenization of equipment for transmission and distribution, and equipment which could be used in other sectors, such as motors, transformers[45/], etc., could be relevant.

57. Every country has different priorities for different sectors and some countries may find it more worthwhile to go for indigenization of transport equipment or agricultural machinery or machine tools or consumer goods[46/]. Here again, the question of overall national objectives and hence priorities for industrialization comes into forefront because it may not be possible to pursue many goals at the same time given limited financial and manpower resources. Therefore, whether the electric power sector has a relative priority over other sectors or not needs to be determined in the overall economic planning.

58. The most important argument of the present time against the domestic manufacturing in the developing countries is that, regarding surplus capacity at the global level due to the falling demand or zero growth in demand in the market economy developed countries, there would be an increased opportunity for trade between developed and developing countries[47/]. Unfortunately, this has not led to a spurt in purchases by the developing countries. Several reasons could be considered:

a) The falling demand in the market economy developed countries has caused the capacity utilization to decline and, consequently, the

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45/ UNIDO; Establishment of factories in developing countries for the production of electric distribution transformers, UNIDO/IOD.139, 1978.
46/ Op. cit. 3/.
47/ Op. cit. 10/.

overheads to increase. Therefore, the prices of imports by the developing countries have increased. Of course, the costs of domestic activities, such as civil works, in the developing countries have gone up too, but a significant price increase in high technology items has taken place. The high exchange rate for the US dollar since 1982 has only worsened the problem. Even if some prices did not go up in US dollars, there is nearly a 60 per cent rise in the value of the dollar itself as measured against the national currencies of most developing countries during this period.

b) The tightness of availability of finance has also led to great restraint on the part of the developing countries as well as on the part of the financing agencies.

c) The developing countries of Group A, which could provide large markets for the manufacturers in the industrialized countries, have only recently acquired self-sufficiency in domestic manufacturing and are at cross-roads whether to support the domestic firms by giving them the opportunity or to go for better equipment available from foreign firms, which, sometimes, also brings external finance in the bargain.

59. Thus, there is a conflict between short-term goals of obtaining the electric power plants rapidly and long-term objectives of increasing self-reliance. A tricky balance between the two can be achieved with far-sighted policies. The slow process of training which requires to bear the costs of "learning by doing" and to put faith in the national talents and capabilities are the kind of measures required for building up technological self-reliance.

60. Political uncertainties tend to emphasize short-term gains. The turn-key projects are easier to negotiate (but expensive to pay) and usually delivered within the stipulated time. The international financing agencies usually require global tenders as a condition to provide funds. These agencies, are more concerned with reliability and speedy delivery rather than indigenization. Although it should be pointed out that in some countries, turn-key projects may be difficult to justify even on these two grounds.

61. Taking many factors into account, ranging from surplus capacity, finance, etc. to technological constraints, different developing countries may wish to pursue the policies of indigenization at different levels and through different modes. However, in all cases, there is a basic need to develop the indigenous capacity to obtain basic understanding for technology unpackaging. While unpackaging technology to manufacture all types of equipment may be

possible for only a few countries, the unpackaging of the turn-key projects should be possible for a very large number of developing countries of Group A and Group B and many from Group C. Such unpackaging, first of all, requires a team of competent individuals with strong support of the Government, so as to bargain better and to specify clearly all the technical parameters of their own requirements. Even in case of a turn-key import, such a team would ensure better delivery and stipulate contractual terms so as to avoid misunderstandings which could lead to delays, increased costs or inadequate returns for their money.

CHAPTER 5

TRENDS IN THE EXPORTS OF ELECTRIC POWER EQUIPMENT

5.1 Introduction

62. Before one goes into formulation of policies and strategies, there is a need to look at the basic facts, recent trends and current positions with regard to production and trade of the electric power equipment. The analysis here is limited to the trade aspects since the reliable production data is not widely available. It may be argued, however, that some of the inferences could also be drawn with regard to manufacture of the electric power equiment from trade data, albeit indirectly. Discussions below are split into three categories:

a) Some global trends at three digit levels 48/;

b) Structural changes in the trends;

c) Specific trends of exports and imports by countries or groups of countries.

5.2 General trends

63. The global trends are illustrated in a short summary given in Table 5.1. It can be seen that in current US dollars, the total world exports amounted in 1970, 1980 and 1983 to US$ 13, 39 and 34 billion, respectively, of which the corresponding shares of developing countries were 27, 37 and 32 per cent, respectively. The shares, however, show variations for different equipment: In 1983, for the electricity distributing machinery it was nearly 45 per cent,

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48/ These are aggregate levels classifying equipment into non-electric power generating machinery, electric power machinery and switch gear, and electricity distribution machinery classified by SITC code nos. 711, 722 and 723, respectively. These are not the only equipment required for electric power system. Therefore, the actual total trade figures would be larger.

Table 5.1 Summary of the world trade in the electric power equipment (in US$ billions and current prices)

	Non-electric power generating machinery SITC Code: 711				Electric power machinery and switchgear 722				Distribution machinery 723				Total			
	70	75	80	83	70	75	80	83	70	75	80	83	70	75	80	83
Total world exports	7.5	12.9	17.9	17.5	4.5	10.0	17.4	13.3	1.2	2.6	4.0	3.1	13.2	25.5	39.3	33.9
Total exports to developing countries	1.9	3.8	5.9	4.5	1.3	3.7	6.7	5.0	0.4	1.3	2.0	1.4	3.6	8.8	14.6	10.9
Shares of exports to developing countries in the world total (%)	25	29	33	26	29	37	11	10	36	49	48	45	27	35	37	32

Source: UN Trade statistics.

This table includes only the equipment under SITC Code nos. 711, 722 and 723. However, there are many other items, such as controlling and measuring equipment, fuses, fuel and ash handling systems, cooling system equipment, water pumps, etc. which are not included here. It may be assumed that these commodities may add 20-30% to the totals indicated in this table.

whereas for non-electric power generating machinery such as boilers, turbines, etc., it was 26 per cent.

5.3 Structural changes

64. The detailed trade data is given in Annex II. It is evident from this data that there have been several structural changes which have taken place over the period 1970-1980. The highlights are discussed below.

65. There was a substantial rise in the total world trade of electric power equipment from US$ 13.2 billion to US$ 39.3 billion during the period 1970-1980. The peak reached in 1980 dropped to US$ 33.9 billion in 1983. This drop is mainly due to the reduced electricity demand, which has become a worldwide phenomenon and has been especially the case for the developed countries. The reasons, however, are different for developed and developing countries. While in the developed countries it is in part due to increased efficiency of electricity utilization, in the developing countries it is mainly due to their inability to finance such imports.

66. The share of developing countries in the world market went up from 27 to 37 per cent from 1970 to 1980 but declined to 32 per cent in 1983. This is somewhat surprising because the fall in the electricity demand is much greater in the developed countries compared to the developing countries. This could be explained only partially by the increased ability to domestically manufacture the equipment and by lack of financial means compounded by the reduced demand even in the OPEC (Organization of Petroleum Exporting Countries) countries. However, a closer look at a number of other aspects is required before one could fully explain this.

67. Among the major exporters are the USA, Japan and other OECD (Organization for Economic Co-operation and Development) countries. For the purpose of this paper, NICs of Group A are also included as exporters. For commodity group 711, the value of exports in current dollars went up from 1970 to 1980 by nearly 8, 2, 4 and 2-fold for NICs, USA, Japan and other OECD countries, respectively . These increases were even larger for commodity groups 722 and

723. However, the sharp reduction over 1980 values took place for all commodities.

68. For all the three commodity groups, the shares of NICs and the USA in the world exports during 1970 to 1983 remained the same with some minor fluctuations. Since the share of Japan increased all along from 1970 to 1983, the shares of the exports of the other OECD countries fell considerably. This is rather surprising considering that the value of the US dollar was higher in 1983 compared to 1980 and these countries would be expected to be more competitive than the USA.

69. The share of NIC imports in the world total has been around 8 to 10 per cent. The share of imports of other developing countries has increased from 1970 to 1980 but declined in 1983. The share of other OECD countries also declined but the share of the USA went up. In fact, it is surprising that the USA imports are rather large, around 25 per cent of the total world imports. The USA imports mainly from the other OECD countries, but is increasingly switching to the NICs, mainly to Mexico and Singapore.

70. The question of re-exporting from foreign subsidiaries and exports to third countries by these groups merits some study but is beyond the scope of this paper. For example, the USA exports for commodity groups 711, 722 and 723 in 1983 are US$ 5.0, 2.0 and 0.5 billion, respectively, but USA imports for the same commodities amounted to US$ 3.4, 4.9 and 0.4 billion, respectively. Although, these general commodity groups involve a large number of specific items, diversity alone does not explain this phenomenon in a single country. However, export-import within the group of other OECD, notably the EEC (European Economic Community) group, which consists of several countries, is to be expected. The trade within the group amounts to more than 50 per cent of the world trade. There is very little trade between the NICs and how to increase their co-operation among themselves needs to be looked into.

5.4 Exports of electric power equipment from developing countries

71. The exports of electric power equipment from developing countries form a

small share of total world exports but nonetheless are important to those developing countries which export them. This is especially the case for the NICs, i.e. Group A countries. Many of them had pinned their hopes on exports of engineering goods. This was, in fact, the motivation behind major efforts and investment for most of the countries in this group. However, as can be seen from Table 5.2, these hopes which seemed to realize in 1980 with a rewarding rise in the exports of electric power equipment compared to 1975, took a sharp downward plunge in 1983. This may be due to reduction in the electricity demand and subsequent excess global capacity to manufacture electric power equipment, which led to strong competition. The NICs were obviously unable to face it, given also the handicap of lack of means of finance. In fact, even within their own countries, the domestic firms lose out to foreign firms who come with offers packaged with financial aid or loans.

72. With regard to awarding of export contracts, those countries that are able to come up with means to finance the projects either from the Government or from the international agencies are more successful in getting the contracts. Thus, Brazil, India and the Republic of Korea, unable to raise finance from their own Governments for export projects, find it difficult to obtain the contracts for external projects.

Table 5.2 Exports of the electric power equipment by the NICs (Group A) in 1975, 1980 and 1983 (in US$ millions and constant 1975 prices)

Importer		SITC Code: 711			722			723		
Exporter	Year	NIC	Other Dvlpg	World	NIC	Other Dvlpg	World	NIC	Other Dvlpg	World
Argentina	75	3	7	13	3	7	10	-	4	6
	80	4	12	23	3	6	11	-	6	8
	83	-	-	6	-	-	1	-	-	-
Brazil	75	2	29	114	9	18	34	-	3	5
	80	16	34	240	30	33	79	2	7	10
	83	8	19	300	6	18	55	2	19	25
China	75	2	5	8	2	20	23	1	3	4
	80	3	11	17	2	3	38	1	16	18
	83	1	5	9	4	30	36	1	5	6
India	74	1	23	35	1	18	21	1	10	23
	80	1	40	52	-	23	27	-	2	15
	83	-	-	7	2	-	7	2	-	5
Rep. of Korea	75	-	2	2	1	4	40	-	14	17
	80	-	5	46	3	26	110	2	39	45
	83	-	-	4	2	5	102	8	3	23
Mexico	75	-	1	48	1	5	11	1	10	12
	80	-	1	56	2	2	260	-	4	120
	83	-	-	400	-	-	364	-	-	217
Singapore	75	1	26	62	2	50	85	-	7	8
	80	6	52	95	4	66	210	-	2	23
	83	13	64	138	6	98	474	-	17	21
Total NIC	75	10	101	282	17	122	224	3	52	76
	80	33	157	530	44	189	736	6	95	241
	83	12	89	864	20	152	1040	13	44	298

<u>Source</u>: United Nations Trade Statistics, 1982.

711: Power generating machinery, other than electric
722: Electric power machinery and switchgear
723: Electric distribution machinery

CHAPTER 6

SOME ADDITIONAL FACTORS FOR THE MANUFACTURE OF ENERGY-RELATED CAPITAL GOODS

6.1 Introduction

73. Development of electric power equipment industry needs to be considered in a much broader framework which also includes other factors, such as requirements of engineering services for power systems and power projects, and availability of raw materials. Moreover, as and when new and renewable energy sources are developed, such as bio-mass, wind and solar energy, etc., a new approach will be required for energy development in general, and for manufacture of energy-related capital goods in particular.

6.2 Required engineering services and training

74. The implementation of electric power projects requires engineering services as much as equipment. These services are varied and extensive in nature. They often call for skills which are not readily available in the developing countries. They are required mainly at three stages:

a) **Prior to commissioning a project:** These include services for geological and seismic surveys, siting, project planning, carrying out feasibility studies, developing design specifications, etc. These services require a group of highly trained persons and hence the development of national engineering and consultancy capability. This capability is often available in group A countries. In the countries of group B where foreign assistance is often necessary for power generation projects, these services are not always available. It is, therefore, necessary for them to give priority to the development of these services.

b) **Constructing a project:** This requires services for constructing buildings, dams, structures, roads, laying railway lines, laying pipelines; assembly of equipment and installations for generation, transmission and distribution, and implementation of rural electrification projects. When most of these services could locally be provided, the share of local labour could be more than 50 per cent of the total services required. In addition to unskilled labour. these also require skilled services and supervision. The countries of group A are able to provide most of these services domestically, except for occasional assistance for solving some exceptionally difficult problems. The countries of group B often need to work together with countries from which technologies are imported, especially for power generation and high-voltage transmission. The countries of group C which are almost totally dependent on acquiring turn-key projects should initiate efforts to indigenize some of the services above.

c) **Repair and maintenance of facilities:** Repair and maintenance of electric power installations such as thermal, nuclear or hydro power plants and transmission and distribution systems, requires services of skilled labour as well as some routine work. Moreover, spare parts could require as much as 10 to 25 per cent of the total investment. Except for some occasional assistance from abroad for special problems, group A and group B should be able to find the manpower required for maintaining energy facilities domestically. This is not the case for some countries of group C and especially the least developed countries. Furthermore, the experience has shown that the effectiveness of repair and maintenance could substantially increase if the same team was trained and work in the assembly phase as well. It could also be argued that repair and maintenance could also constitute a possible route of entry into the the manufacture since most of the technical and technological knowledge required for the production have to be mastered for effective repair and maintenance.

6.3 Backward and forward linkages

75. These linkages are illustrated in Figure 6.1. Since the forward linkages with the end-user sectors, which determine the need for electricity and hence the electric power equipment, have already been discussed in Chapter 2, the discussion here will concentrate on the backward linkages or prerequisites. The first prerequisite is, of course, the availability of energy resources for electricity, which may be either mineral (fossil or nuclear) or renewable (hydro, solar, wind, etc.). The second one is the availability, in sufficient numbers, of skilled and unskilled labour. Another concern is the availability of components and the raw materials for electric power equipment. The major raw materials required for manufacturing are iron and steel, cement, copper and aluminium. Steel could be of various types: carbon steel, stainless steel, low steel alloy, silicon oriented steel, etc., each of which requires different levels of technological development. In Table 6.1, the data reported by Bechtel Co. for constructing some of the electric power facilities, mainly in the USA, are analyzed and scaled for 100 MW power plants without considering the economies of scale which may be there for larger plants such as 500 MW and above. Therefore, the required raw materials for an

actual 100 MW plant may be higher than those indicated in Table 6.1.

76. It can be seen from Table 6.1 that dam construction and hydro-power requires much more cement, concrete, steel, copper and aluminium. Thus, tapping renewable energy resources implies using non-renewable metal and mineral resources. Surprisingly, nuclear power requires comparable amounts of cement and steel as hydro power. The requirements in terms of materials for oil- and gas-based power plants are less than those needed by coal plants. Geothermal power, on the other hand, requires more steel but not that much cement. The plant that requires the least materials is the latest gas-turbine technology.

77. Table 6.2 shows that while the number of developing countries having primary resources, such as iron ore, bauxite or copper, is high, the number of those having the technology to process them is small. Many of them are simply exporting the primary ore and do not have the expertise in metallurgy such as smelting, casting, rolling, forging, etc[49/]. Comparison of data contained in Table 6.2 and other information with regard to manufacture of electric power equipment in the developing countries demonstrates that there is a high correlation between the capability for processing metals and manufacturing electric power equipment. The generalization of this observation is possible by comparing, for each developing country, the iron and steel production[50/] and the development stage of capital goods industry[51/].

6.4 Capital goods for New and Renewable Sources of Energy (NRSE)

78. At present, the contribution of NRSE for electricity is negligible, and no data is available for manufacture and/or trade of capital goods for electricity generation from NRSE. However, it is essential to draw some implications of a policy to pursue the development of NRSE:

49/ UNIDO; The development and restructuring of the non-ferrous metals industries, ID/WG.436/1, 1985.

50/ UNIDO; 1990 Scenarios for the iron and steel industry, UNIDO, ID/WG.374/2 and Add 1, 1982.

51/ UNIDO; The second world-wide study on capital goods: The sector in figures, UNIDO/IS.505, 1984.

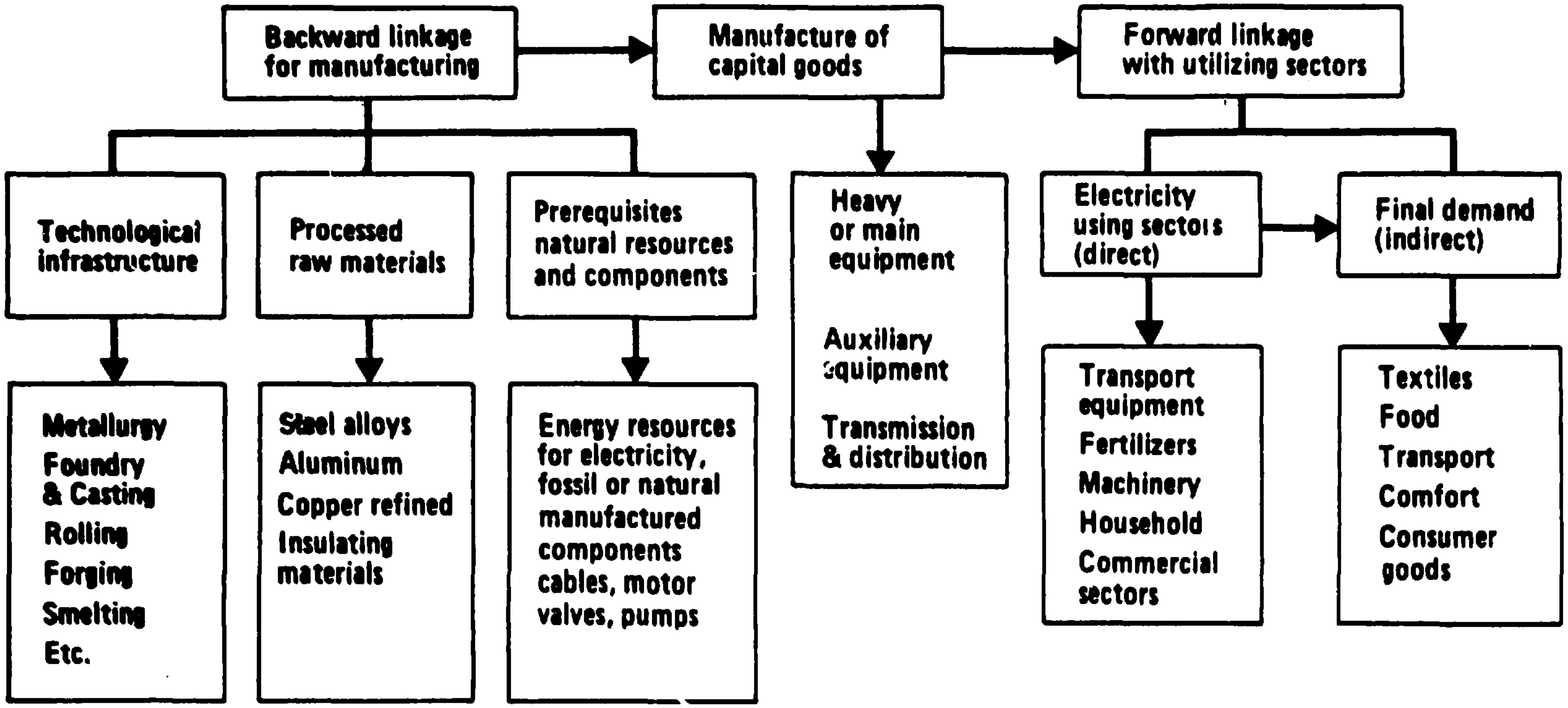

Figure 6.1 Backward and forward linkages essential for the manufacture of electric power equipment.

Table 6.1 Material requirements for 100 MW power plants

Type of facility	Size MW	Material requirement, 1000 tons							
		Carbon steel	Low steel alloy	Stain-less steel	Total steel	Copper	Alumin-ium	Con-crete	Cast iron
Oil-fired	100	1.76	0.138	0.044	1.942	0.064	0.015	10.70	0.03
Coal-fired	100	2.60	0.180	0.044	2.824	0.130	0.030	17.50	0.05
Gas-fired	100	0.90	0.087	0.020	1.000	0.048	0.010	6.26	0.02
Gas turbine	100	0.30	0.022	0.006	0.500	0.021	0.005	1.57	0.01
Nuclear	100	4.30	0.430	0.182	5.000	0.207	0.060	50.76	0.08
Hydro	100	5.80	0.144	0.017	6.000	0.138	0.340	75.00	0.23
Pumped storage	100	4.10	0.071	0.010	4.180	0.070	0.016	58.80	0.005
Geothermal	100	6.30	1.000	0.360	7.660	0.250	0.067	5.50	0.313

Source: The compiling and scaling were done using data contained in "Bechtel Corporation; Availability of selected materials and equipment commodities for US energy development program, Report No.E(49-1)-3794, 1976".

Table 6.2 Minining of raw materials and processing in developing countries

Iron ore		Bauxite		Copper ore	
Argentina	■	Brazil	■	Bolivia	
Brazil	■	Dom. Republic		Botswana	
Chile	■	Ghana		Chile	■ ●
Colombia	■	Guinea		Cuba	
Egypt		Guyana		India	■
India	■	Haiti		Indonesia	
Indonesia		India	■	Korea Rep.	■ ●
Korea Rep.	■	Indonesia		Mexico	■
Liberia		Jamaica		Morocco	
Malaysia		Malaysia		Namibia	■
Mauritania		Sierra Leone		Peru	■ ●
Mexico	■	Suriname		Philippines	■
Morocco		Turkey		South Africa	■ ●
Peru				Turkey	■ ●
South Africa	■			Zaire	■ ●
Thailand				Zambia	■ ●
Tunisia	■			Zimbabwe	■
Turkey	■				
Venezuela	■				
Zimbabwe					

Source: UN Yearbook of Industrial Statistics (1981)

■ Indicates processing activities, i.e., production of steel, aluminum and copper smelting, respectively

● Indicates refined copper

a) Rural development is a priority issue in many developing countries. The required energy input for rural development programmes could be supplied, to a large extent, by NRSE;

b) The overexploitation of commercial and non-commercial energy resources (such as fuel wood) in many rural areas makes it necessary to mobilize efforts to develop NRSE;

c) In some developing countries with a large surface area, there is a practical problem to connect the remote areas to the national electricity grid. In such cases, decentralized electricity generation offers a solution. In particular, small-scale hydro power, wherever the water resources exist, appears to be an optimum solution[52/];

d) The equipment requirements for NRSE, generally, involve low and medium technology items. A large fraction of these equipment could be manufactured by rural and/or small-scale capital goods industries of many developing countries[53/].

79. Some examples of the low or medium technology equipment necessary for NRSE are given below:

- Bio-gas digesters, if bio-gas is used as fuel, could be manufactured in the rural workshops and/or small-scale industries. Some components such as pipes for transporting gas, good quality burners and the gas holders may have to be obtained from manufacturers located in urban areas. If used for electricity generation, it requires additional hardware (eg. boiler, turbo-generator, etc.), which are of higher technological complexity and beyond the capability of rural industry.

- Micro- and mini-hydro power stations are discussed in detail elsewhere[54/]. Manufacture of a large fraction of equipment and construction works required by such installations could be carried out by rural and/or small-scale industries and by local skills.

- Wind mills, if used for mechanical purposes, require low technology items. However, if used for electricity generation, they would require generators which are medium or high technology items.

- Solar energy, if tapped with collectors or concentrators for water heating or cooking or drying does not, generally, require high technology items. However, solar power plants in general, and photovoltaic equipment for electricity generation in particular require the utilization high technologies.

52/ UNIDO; Mini-hydro power stations: A manual for decision makers, UNIDO/IS.225, 1981.

53/ - Op. cit. 3/.

54/ Op. cit. 51/.

80. However, there are two conditions which must be fulfilled for successful exploitation of NRSE:

a) Most of the NRSE applications require accurate siting and co-ordinating. For example, height and location of a wind mill are so crucial that if it is placed 50 meters away from the optimal site, it could mean a substantial reduction of the performance. Similarly, angle and location of solar equipment or height and site of mini-hydro power plants are crucial. One may argue that this is also the case for large hydro-power plants, but this has to be done only once to get large amounts of power. In the case of NRSE these investigations have to be done many times over for equivalent amounts of energy. Thus it would require a different spread of skills than the present approach used in large-scale centralized energy production where a team of persons with high, medium and low skills operates together.

b) If a large contribution from NRSE is to be expected, then "economy of scale" has to be replaced by "economy of number". For example, hundreds of wind mills would be required to replace a conventional power plant of 200 MW. The same holds for bio-digesters and solar collectors so as to replace a ton of oil. This is certainly possible as has been demonstrated in some developing countries.

6.5 Organizational and institutional aspects

81. These aspects are just as important, if not more, as technological capabilities. First of all, for all developing countries integrated energy and industry planning is necessary to identify the requirements while keeping the national objectives and economic development in view. This activity requires the creation of planning organizations and/or teams at high level in the Governments.

82. The next stage is at the project level. For successful technology unpackaging, the first requirement is the creation of national engineering and consultancy services. This appears to be a top priority action for Group B and for some Group C countries. Starting even with the turn-key mode, establishment and effective use of such services is, probably, the only way in which the purchasing power of the developing countries could be utilized in strengthening the negotiating position and increasing the national participation.

83. For execution of large projects such as electric power projects, basically the same organizations are required as any other large industrial project would require, namely, planning, scheduling, engineering, project management/supervision and construction departments. The following is a typical example to give an idea of the workloads of some of these departments: For a 340 MW coal-fired thermal power plant, one company in the USA required 200,000 man-hours for engineering and design and 300,000 for construction management.

84. Taking over gradually the management and construction site should be rewarding in terms of employment, the levels of skill-development required and percentage of costs involved (which could amount to as much as 50 per cent of the project total)[55/]. There is scope for almost all developing countries to participate in construction works. In particular, construction works for rural electrification offers a suitable starting point for countries of Group C.

55/ Op. cit. 5/.

CHAPTER 7

CONCLUSIONS AND POSSIBILITIES FOR INTERNATIONAL CO-OPERATION

7.1 Introduction

85. The data presented in the preceeding chapters and their analysis would lead to several conclusions. Furthermore, analysis of policies and strategies of different parties involved in the electric power sector with regard to the requirements of the developing countries would enable the identification of possibilities and/or opportunities for international co-operation.

7.2 Government action

86. The experiences of developing as well as those of developed countries reveal the fact that Government plays a central role in the development of electric power equipment industry. In particular, the electric power utility company in the developing countries is, almost always, a state enterprise. This makes the Government the largest purchaser of electric power equipment. Therefore, clearly stated and concretely implemented Government policies would be the key to successful attempts to indigenization in the sector. The Government actions could cover a wide spectrum from planning to utilization of purchasing power, and from direct public investment in the manufacturing to incentives to private manufacturers and protective trade regulations.

87. The Governments of developing countries, first of all, need to recognize that there is a strong interdependence between the industry and energy sectors in general, and between the industry and electric power sectors in particular. Therefore, the development of electric power equipment industry has to be viewed in the context of overall national objectives. Such an approach necessitates the integrated planning of energy and industry. For this purpose, planning teams and/or organizations should be set up with specialists having different backgrounds related to energy and industry.

88. The planning should start with estimating the future demand for energy and, in particular, for electricity. This requires the long-term analysis of forward linkages, i.e., the long-term requirements of electricity utilizing sectors. Following the identification of demand levels and the expected rates of growth, the long-term availability of energy resources should be assessed so that the optimal energy mix could be determined. This work should also identify the types and mix of electricity generation (hydro, conventional thermo --coal or oil-fired, nuclear, etc.). Requirements of rural development programmes and rural electrification schemes should also taken into account in the planning.

89. Domestic manufacturing of electric power equipment, either for import substitution or exporting purposes or both, is an issue where short-term electricity needs have to be balanced with long-term industrial goals. The former would prefer a sure and quick way to obtain electricity, the latter requires sustained efforts to develop local skills and giving them the support they require to learn-by-doing. The balance will naturally depend on the costs of imports, envisaged long-term demand of power equipment and acceptable relative differences between the delivery periods by each route. These are the additional factors to be considered by the electricity-planning teams.

90. Depending on the size of the annual demand increment and the level of development of capital goods industry, the planning agencies may decide which types of equipment should be domestically manufactured (see Chapter 3). Suitable modes of development need to be also selected for each type of equipment (see Chapter 4), reducing external dependence. In country groups B and C, organizations have to be strengthened to gradually take control of on-site management leaving imports of only selected hardware. Different characteristics of these country groups, possible equipment they could manufacture, types of training they require, modes of obtaining equipment are indicated in Table 7.1[56/].

56/ For a more detailed treatment see: Op. cit. 5/.

Table 7.1 Country groups: Training, equipment and co-operation

Country group/ characteristics	Trained manpower and organizations required	Types of equipment which would be manufactured	Modes of obtaining equipment and co-operation required
Group A		Additional to Group B	
-Installed capacity 12-76 GW* -Annual increment, multiple of 1000 MW* *Except Singapore	-Training in design and modifications; -Quality control, testing and certification of standards for medium and high technology items; -On-site, in-office and in-factory management and organization; -Research and development for more appropriate designs for local conditions; -Learning about licensing procedures, terms and negotiations.	Medium and high technology items such as boilers, turbines, generators, power transformers, high voltage transmission lines, measurement and control equipment.	-Through foreign subsidiaries of TNCs in the country; -Manufacturing from foreign licence; -Joint ventures; -Sharing of experiences with licensing, performance evaluation, indigenization, etc.; -Increasing national participation in the projects.
Group B		Additional to Group C	
-Installed capacity 1-9 GW -Annual increment multiple of 100 MW	-Training in quality control, standards and testing at low and medium technology; -Greater control of on-site work; -Supervisory services.	Low and medium technology items, including insulators, switchgear, water turbines, transmission towers, etc.	-Assembly of imported items, subsidiaries and manufacturing under licence for items other than high technology; -Exchange of experiences, access to technical information
Group C			
-Installed capacity less than 1 GW -Annual increment multiple of 10 MW	-Maintaining power equipment; -Energy planning and electricity planning; -Negotiating turn-key projects or assembly of components; -Co-ordinating on-site projects; -Local labour for construction; -Low technology manufacture.	Low technology items, cables, fuses, poles, pipes, switches, distribution transformers (depending on the size of the country).	-Imports of components; -Information system for prices and specifications for better negotiations with firms abroad; -Gradual increase in on-site management.

91. Irrespective of the policies and strategies adopted, the creation of national engineering and consultancy capacity appears to be the first prerequisite for the development of electric power sector. These technical services are required not only for indigenization efforts but also for identification and, later, utilization of the co-operation opportunities as discussed below.

7.3 Co-operation between developed and developing countries

92. The co-operation between developed and developing countries could be in one or a combination of the following forms (see Chapter 4):

- Turn-key projects carried out by firms from developed countries;
- Direct exports of equipment and services by developed countries;
- Manufacturing by subsidiaries of TNCs from developed countries in developing countries;
- Manufacturing by joint ventures in developing countries;
- Transfer of technology to firms in developing countries;
- Direct exports of equipment by developing countries.

93. A set of parties from the following is involved in each of the above co-operation arrangements:

a) **In developing countries:** Governments, investment banks and other financing agencies, utilities, software service companies, construction firms, electric power equipment manufacturers, etc.;

b) **In developed countries:** Governments, financing institutions, electric power equipment manufacturers (TNCs and SMEs --small- and medium-sized enterprises), software service companies, civil engineering and construction firms, etc.;

c) **International organizations:** Multilateral and international financing organizations, technical assistance organizations, associations of electric power equipment manufacturers, international standards organizations, etc.

94. The large number of parties involved in the electric power projects increases the complexity of negotiations and co-operation arrangements. However, two areas are common to all modes of industrial activity: Information and training. Commercial and technical information with regard to availability, cost, technical specifications, etc. of equipment, systems and technologies are of vital importance to the decision makers in developing countries. Training in general, and on-the-job training at the facilities of the manufacturer and on the power system in the developing country in particular, are needed to create the skills pool of the electric power and power equipment industries. Training programmes should also cover the areas such as energy and electricity planning, power system management, and repair and maintenance.

95. Co-operation in the information and training areas would help to create national engineering capacity in developing countries. As discussed before, this would be the the only route through which the developing countries could strengthen their negotiating position and increase their participation in electric power projects.

96. Many Group A countries (NICs) which manufacture some electric power equipment face the requirement of making product and process modifications in order to adopt them to their specific conditions. Although the majority of these changes aims at simplifying the product designs and/or processes, some others are required to cope with the specific operating characteristics of the power systems in developing countries, and can be fairly complex. Mastery of designs and technologies requires close co-operation between the donors and receipients of technology and involves training of personnel of the latter.

97. In most of the cases, the developing country has to negotiate with two parties, namely, the supplier of technology and the financing agency. In fact, the financing agency could be powerful enough to dictate the source of equipment and/or the mode of project implementation. The experience has shown that the financing agencies have preferred the turn-key mode due to a variety of reasons. Therefore, the indigenization policies should consider this factor and should lead to project designs which would allow domestic participation and, at the same time, be viable for external financing.

7.4 Co-operation among developing countries

98. Since the developing countries share common problems, they could benefit greatly by co-operating in a variety of ways, ranging from sharing energy planning methods to manufacturing jointly, and from establishing common information systems to organizing training programmes, visits and seminars.

99. One area of great interest to all developing countries is the establishment of common information systems which would include their technical and commercial experiences and performance evaluation assessments. Through utilization of such information, better terms could be obtained for the contractual arrangements of various types. In view of the substantial purchase of equipment and other services by the developing countries, a consumers' association, similar to that of manufacturers, or other channels of information exchange should be developed.

100. Intensified efforts should be made by the electric power equipment exporting developing countries of groups A and B to understand better the needs of the other importing developing countries. Furthermore, the trade and co-operation among Group A countries (NICs) are very insignificant. This channel needs to be strengthened to share experiences in domestic manufacturing whether through licences or joint ventures or subsidiaries.

7.5 Regional co-operation

101. This could be a special case of co-operation among developing countries. It could be along two different lines: Among almost equals of country groups B and C, and between a Group A country and its neighbours.

103. It is interesting to note that the electric power sector has all the properties calling for regional co-operation. Yet, the examples of such co-operation among the developing countries are not many. Interconnection of national electricity networks between neighbouring countries could generally be taken as the first step towards regional co-operation. Interconnection makes it possible, firstly, better utilization of installed generation

capacities and easier handling of peak power demands. Secondly, it promotes regional co-operation through which the markets could be expanded to reach economic scales for manufacturing. This puts the neighbouring countries in a stronger negotiating position vis-à-vis the technology owners.

104. Joint electric power equipment manufacturing projects between developing countries are another form of co-operation. The parties in such projects may own no technology themselves; then joint technology transfers from third parties are necessary. In some other cases, one of the parties may have already transferred and/or developed the technology; then the implementation could be similar to those projects involving developed and developing countries.

105. Even without interconnections and/or joint manufacturing projects, it is extremely important that the developing countries of the region exchange technical and commercial information on their electric power systems. Technology unpackaging in general, and project design, contract negotiation, prices, operation and management in particular, are important areas for information exchange.

106. Another barrier to regional co-operation between developing countries is the insufficient institutional framework to promote such co-operation. For this purpose, much work has to be done at regional and international levels. Close co-operation between international organizations concerned with the subject is also needed. One possible first step could be the establishment of regional associations of utilities and/or manufacturers of electric power equipment.

107. One of the main technical barriers hindering the regional co-operation is incompatible standards. Standardization, therefore, emerges as the first issue to be dealt with. Every effort should be spent to formulate common standards and to eliminate non-technical and/or commercial reasons for adopting different standards.

108. Regional testing facilities need to be set up with standard practices of quality control and certification systems. The participating countries of the

region could benefit from the services of these facilities in manufacturing, joint purchasing or sharing information conc rning imported equipment.

7.6 Role of international agencies

109. International agencies could play an important role in assisting the developing countries to negotiate better at each stage whether it is a turn-key project or manufacturing under licence. Assisting the setting-up of associations among developing countries which would be familiar with the legal, economic, financial, technical and other contractual aspects of electric power system projects, may be helpful in negotiating such contracts. The key to improvements in negotiations is the information system mentioned above which could be supervised by the international agencies so as to include impartial, correct and complete information.

110. While international funding agencies may wish to advocate global tenders for the projects they finance, recognition should be also given to the legitimate desires of developing countries to use as many components and equipment manufactured in their own countries. The steps to gradual realization of these goals should be identified.

111. Organization of symposia or seminars to share experiences of developing countries that manufacture as well as those who import equipment would be useful. These could be supported by visits and by demonstration projects.

112. Those developing countries who wish to share hydro-projects or electricity from a large thermal plant could benefit from arbitration or overseeing of international agencies so as to deal with each other. Some of the other items considered in 7.4 above could also benefit from assistance that can be extended by the international organizations.

Annex I

Installed capacity and generation of electricity

1. Growth of installed capacity (in GW and %)

	1960	1970	1975	1980	1982	Growth rate, % 70/60	75/70	80/75	80/70	82/80
WORLD	520.6 (100.0)	1125.4 (100.0)	1606.1 (100.0)	2013.1 (100.0)	2160.7 (100.0)	8.0	7.4	4.6	6.0	3.6
DEVELOPED COUNTRIES	484.4 (93.1)	998.3 (88.7)	1406.2 (87.6)	1707.5 (84.8)	1813.4 (83.9)	7.5	7.1	4.0	5.5	3.0
Market Economies	393.6 (75.7)	782.4 (69.5)	1117.4 (69.6)	1351.5 (67.1)	1431.4 (66.2)	7.1	7.4	3.9	5.6	2.9
Centrally Planned	90.8 (17.4)	215.9 (19.2)	288.8 (18.0)	356.0 (17.7)	382.0 (17.7)	9.0	6.0	4.3	5.1	3.6
DEVELOPING COUNTRIES	36.1 (6.9)	126.4 (11.2)	198.7 (12.4)	304.2 (15.1)	345.9 (16.0)	13.4	9.5	8.9	9.2	6.6
Africa	4.2 (0.8)	13.5 (1.2)	17.5 (1.1)	24.3 (1.2)	25.8 (1.2)	12.4	5.3	6.8	6.0	3.0
Americas	19.0 (3.6)	42.7 (3.8)	65.9 (4.1)	99.3 (4.9)	113.8 (5.3)	8.4	9.1	8.5	8.8	7.1
Asia	12.9 (2.5)	70.2 (6.2)	115.3 (7.2)	180.6 (9.0)	206.3 (9.5)	18.5	10.4	9.4	9.9	6.9

Source: United Nations, 1982 Yearbook of world energy statistics

Figures in paranthesis refer to shares in total world capacity in percentage.
GW = 1,000 MW = 1,000,000 kW

2. Distribution of installed capacity and generation of electricity in 1982

	Rank	Total capacity GW	% World	Cumulative capacity GW	Cumulative capacity % World	Production TWh
WORLD		2160.7	100.00			8436
100 GW						
United States	1	666.4	30.84	666.4	30.84	2304
USSR	2	285.5	13.21	951.9	44.06	1367
Japan	3	154.8	7.16	1106.7	51.22	581
25 - 100 GW						
Federal Rep. of Germany	4	85.8	3.97	1192.5	55.19	367
Canada	5	83.0	3.84	1275.5	59.03	387
China	6	76.0	3.52	1351.5	62.55	328
France	7	74.0	3.42	1425.5	65.97	266
United Kingdom	8	69.2	3.20	1494.7	69.18	272
Italy	9	50.0	2.31	1544.7	71.49	184
Brazil	10	38.9	1.80	1583.6	73.29	152
India	11	38.8	1.80	1622.4	75.09	139
Spain	12	29.9	1.38	1652.3	76.47	117
Sweden	13	29.7	1.37	1682.0	77.85	100
Australia	14	27.5	1.27	1709.5	79.12	105
Poland	15	26.0	1.20	1735.5	80.32	118
10 - 25 GW						
South Africa	16	23.1	1.07	1758.6	81.39	109
Norway	17	22.1	1.02	1780.7	82.41	93
Mexico	18	21.6	1.00	1802.3	83.41	81

GW = 1,000 MW
TWh = 10^9 kWh (billion kWh)

	Rank	Total capacity GW	% World	Cumulative capacity GW	Cumulative capacity % World	Production TWh
German Dem. Rep.	19	21.1	0.98	1823.4	84.39	103
Netherlands	20	18.7	0.87	1842.1	85.25	60
Czechoslovakia	21	18.1	0.84	1860.2	86.09	75
Romania	22	17.2	0.80	1877.4	86.89	69
Yugoslavia	23	14.8	0.68	1892.2	87.57	60
Austria	24	14.2	0.66	1906.4	88.23	43
Switzerland	25	14.1	0.65	1920.5	88.88	52
Argentina	26	13.5	0.62	1934.0	89.51	40
Belgium	27	12.0	0.56	1946.0	90.06	51
Korea Rep. of	28	11.6	0.54	1957.6	90.60	47
Finland	29	11.1	0.51	1968.7	91.11	39
5 - 10GW						
Venezuela	30	9.3	0.43	1978.0	91.54	39
Bulgaria	31	9.2	0.43	1987.2	91.97	40
Saudi Arabia	32	7.4	0.34	1994.6	92.31	25
Korea Dem.People's Rep.	33	7.0	0.32	2001.6	92.64	40
Denmark	34	6.8	0.31	2008.4	92.95	22
New Zealand	35	6.8	0.31	2015.2	93.27	24
Turkey	36	6.6	0.31	2021.8	93.57	27
Greece	37	6.0	0.28	2027.8	93.85	23
Colombia	38	5.8	0.27	2033.6	94.12	26
Iran, Islamic Rep. of	39	5.3	0.25	2038.9	94.36	18
Portugal	40	5.1	0.24	2044.0	94.60	16
Philippines	41	5.0	0.23	2049.0	94.83	19

	Rank	Total capacity GW	% World	Cumulative capacity GW	Cumulative capacity % World	Production TWh
2.5 - 5 GW						
Hungary	42	4.9	0.23	2053.9	95.06	25
Thailand	43	4.9	0.23	2058.8	95.28	17
Pakistan	44	4.2	0.19	2063.0	95.48	18
Puerto Rico	45	4.1	0.19	2067.1	95.67	12
Ireland	46	3.9	0.18	2071.0	95.85	11
Egypt	47	3.8	0.18	2074.8	96.02	18
Hong Kong	48	3.5	0.16	2078.3	96.19	15
Israel	49	3.5	0.16	2081.8	96.35	14
Peru	50	3.4	0.16	2085.2	96.51	10
Chile	51	3.2	0.15	2088.4	96.65	12
Kuwait	52	2.9	0.13	2091.3	96.79	12
Indonesia	53	2.9	0.13	2094.2	96.92	7
Nigeria	54	2.8	0.13	2097.0	97.05	8
Cuba	55	2.7	0.12	2099.7	97.18	11
Malaysia	56	2.6	0.12	2102.3	97.30	12
1 - 2.5 GW						
Singapore	57	2.2	0.10	2104.5	97.40	8
Algeria	58	2.0	0.09	2106.5	97.49	7
Mozambique	59	1.8	0.08	2108.3	97.57	3
Zambia	60	1.7	0.08	2110.0	97.65	11
Zaire	61	1.7	0.08	2111.7	97.73	4
Morocco	62	1.6	0.07	2113.3	97.81	6
United Arab Emirates	63	1.5	0.07	2114.8	97.88	6
Uruguay	64	1.4	0.06	2116.2	97.94	6

	Rank	Total capacity GW	% World	Cumulative capacity GW	Cumulative capacity % World	Production TWh
Luxembourg	65	1.3	0.06	2117.5	98.00	0.9
Ivory Coast	66	1.2	0.06	2118.7	98.06	2
Zimbabwe	67	1.2	0.06	2119.9	98.11	4
Ecuador	68	1.2	0.06	2121.1	98.17	3
Iraq	69	1.2	0.06	2122.3	98.22	6
Libyan Arab Jamahiriya	70	1.2	0.06	2123.5	98.28	6
Syria	71	1.1	0.05	2124.6	98.33	5
Ghana	72	1.1	0.05	2125.7	98.38	5
500 - 1,000 MW						
Bangladesh	73	0.990	0.05	2126.7	98.43	3.305
Dominican Rep.	74	0.960	0.04	2127.7	98.47	2.965
Tunisia	75	0.929	0.04	2128.6	98.51	3.088
Trinidad and Tobago	76	0.760	0.04	2129.3	98.55	2.260
Panama	77	0.744	0.03	2130.1	98.58	2.700
Jamaica	78	0.740	0.03	2130.8	98.62	2.350
Lebanon	79	0.668	0.03	2131.5	98.65	1.290
Costa Rica	80	0.657	0.03	2132.1	98.68	2.500
Burma	81	0.636	0.03	2132.8	98.71	1.715
Angola	82	0.600	0.03	2133.4	98.74	1.600
Sri Lanka	83	0.562	0.03	2133.9	98.76	2.066
Kenya	84	0.556	0.03	2134.5	98.79	1.804
Cameroon	85	0.531	0.02	2135.0	98.81	1.908
Bolivia	86	0.508	0.02	2135.5	98.84	1.703
El Salvador	87	0.500	0.02	2136.0	98.86	1.500

	Rank	Total capacity GW	% World	Cumulative capacity GW	Cumulative capacity % World	Production TWh
LESS THAN 500 MW						
Guatemala	88	0.473	0.02	2136.5	98.88	1.640
Jordan	89	0.456	0.02	2140.0	98.90	1.511
Oman	90	0.419	0.02	2137.4	98.92	1.160
Nicaragua	91	0.400	0.02	2137.8	98.94	1.045
Afghanistan	92	0.394	0.02	2138.2	98.96	0.976
Paraguay	93	0.370	0.02	2138.6	98.98	1.100
Ethiopia	94	0.319	0.01	2138.9	98.99	0.679
Sudan	95	0.313	0.01	2139.2	99.00	1.010
Liberia	96	0.306	0.01	2139.5	99.02	1.100
Tanzania	97	0.258	0.01	2139.7	99.03	0.720
Lao People's Dem. Rep.	98	0.250	0.01	2140.0	99.04	1.000
Honduras	99	0.240	0.01	2140.2	99.05	1.090
Guinea	100	0.175	0.01	2140.4	99.06	0.498
Senegal	101	0.165	0.01	2140.6	99.07	0.631
Uganda	102	0.163	0.01	2140.7	99.08	0.668
Congo	103	0.149	0.01	2140.9	99.08	0.185
Yemen, Dem.	104	0.130	0.01	2141.0	99.09	0.257
Haiti	105	0.126	0.01	2141.1	99.10	0.360
Malawi	106	0.111	0.01	2141.3	99.10	0.428
Yemen	107	0.104	0.01	2141.4	99.11	0.230
Madagascar	108	0.100	0.01	2141.5	99.11	0.432
Sierra Leone	109	0.095	(.)	2141.6	99.11	0.236
Nepal	110	0.079	(.)	2141.6	99.12	0.198
Mauritania	111	0.055	(.)	2141.7	99.12	0.103

	Rank	Total capacity GW	% World	Cumulative capacity GW	Cumulative capacity % World	Production TWh
Mali	112	0.042	(.)	2141.7	99.12	0.110
Kampuchea, Dem.	113	0.040	(.)	2141.8	99.20	0.136
Burkina Faso	114	0.040	(.)	2142.2	99.14	0.115
Rwanda	115	0.039	(.)	2142.2	99.14	0.163
Chad	116	0.038	(.)	2142.3	99.15	0.065
Togo	117	0.035	(.)	2142.3	99.15	0.085
Somalia	118	0.030	(.)	2142.3	99.15	0.075
Central African Rep.	119	0.030	(.)	2142.3	99.15	0.068
Niger	120	0.023	(.)	2142.4	99.15	0.062
Benin	121	0.015	(.)	2141.4	99.15	0.005
Bhutan	122	0.011	(.)	2142.4	99.15	0.024
Burundi	123	0.009	(.)	2142.4	99.15	0.002

Source: United Nations, 1982 Yearbook of world energy statistics

Table AII.1 Trends in the world exports of non-electric power generating machinery --SITC Code No. 711 (US$ million, constant 1975 prices).

Importers	NIC/Group A -				Other Developing (B+C)				USA				Other OECD				World			
Year	1970	75	80	83	70	75	80	83	70	75	80	83	70	75	80	83	70	75	80	83
Exporters																				
NIC/ Group A	2 0% 3%	10 1% 4%	33 2% 6%	23 2% 3%	46 4% 72%	101 4% 36%	157 4% 30%	89 3% 10%	8 1% 13%	46 3% 16%	160 7% 30%	574 17% 66%	5 0% 8%	121 2% 43%	150 2% 28%	166 2% 16%	64 1% -	282 2% -	530 3% -	864 5% -
USA	212 37% 10%	354 33% 10%	749 41% 16%	582 47% 12%	379 29% 18%	619 23% 18%	991 24% 22%	835 26% 17%	- - 0%	- - 0%	- - 0%	- - 0%	1369 35% 64%	2116 32% 62%	2583 31% 57%	3243 37% 64%	2153 28% -	3401 26% -	4552 25% -	5056 29% -
Japan	80 14% 21%	171 16% 20%	354 19% 22%	282 23% 15%	165 13% 43%	372 14% 44%	654 16% 40%	782 24% 41%	80 6% 21%	130 8% 15%	306 13% 19%	483 14% 25%	50 1% 13%	136 2% 16%	248 3% 15%	329 4% 17%	384 5% -	853 7% -	1615 9% -	1930 11% -
Other OECD	266 46% 6%	517 48% 6%	668 36% 6%	347 28% 4%	684 52% 14%	1577 58% 20%	2199 54% 21%	1536 47% 17%	1188 93% 25%	1541 89% 19%	1928 80% 18%	2350 69% 25%	2444 62% 51%	4020 61% 50%	5096 61% 46%	4616 53% 50%	4821 64% -	8087 62% -	10580 59% -	9268 53% -
World	573 - 8%	1085 - 8%	1841 - 10%	1239 - 7%	1307 - 17%	2727 - 21%	4053 - 23%	3249 - 19%	1282 - 17%	1722 - 13%	2402 - 13%	3428 - 20%	3949 - 52%	6594 - 51%	8350 - 47%	8733 - 50%	7556 - -	12952 - -	17877 - -	17534 - -

* SITC 711 includes boilers, turbines, internal combustion engines, nuclear reactors, etc.. Only important exporting groups and importing groups are mentioned here. Therefore, world does not represent the total of the groups mentioned. The second row of percentages is column-wise and respresents the percentage shares of imports of that group among different exporters. The third row of percentages is row-wise representing percentage shares of that group's exports among different groups of importers.

Table AII.2 Trends in the world exports of electric power machinery and switch-gear --SITC Code No. 722 (US$ million, constant 1975 prices).

Importers	N I C/Group A				Other Developing (B+C)				U S A				Other OECD				W o r l d			
Year	1970	75	80	83	70	75	80	83	70	75	80	83	70	75	80	83	70	75	80	83
Exporters																				
N I C/ Group A	4	17	44	20	16	122	189	152	43	35	367	703	4	13	72	85	66	224	736	1040
	1%	2%	2%	2%	2%	4%	4%	4%	14%	8%	28%	37%	0%	0%	1%	2%	1%	2%	4%	8%
	6%	8%	6%	2%	24%	54%	26%	15%	63%	16%	50%	68%	6%	6%	10%	8%	-	-	-	-
U S A	121	228	463	417	191	532	697	606	-	-	-	-	425	759	962	909	799	1653	2252	2073
	33%	25%	25%	32%	20%	19%	14%	16%	-	-	-	-	16%	15%	12%	16%	18%	17%	13%	16%
	18%	14%	21%	20%	24%	32%	31%	29%	0%	0%	0%	0%	53%	46%	43%	44%	-	-	-	-
Japan	72	200	589	523	153	323	850	963	82	94	298	444	62	129	283	350	383	778	2077	2306
	20%	22%	31%	40%	16%	12%	18%	26%	27%	21%	23%	23%	2%	3%	4%	6%	8%	8%	12%	17%
	19%	26%	28%	23%	40%	42%	41%	42%	21%	12%	14%	19%	16%	17%	14%	15%	-	-	-	-
Other OECD	154	399	606	287	516	1633	2828	1997	171	241	485	547	2093	3846	6270	4104	3158	6606	10826	7302
	42%	44%	32%	22%	55%	59%	59%	53%	57%	54%	37%	28%	78%	78%	79%	73%	69%	66%	62%	55%
	5%	6%	6%	4%	16%	25%	26%	27%	5%	4%	4%	7%	66%	26%	56%	56%	-	-	-	-
World	368	909	1882	1315	937	2754	4824	3741	300	444	1295	1923	2684	4915	7912	5606	4546	9974	17422	13264
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	8%	9%	11%	10%	21%	28%	28%	28%	7%	4%	7%	14%	59%	49%	45%	42%	-	-	-	-

Table AII.3 Trends in the world exports of electricity distributing machinery --SITC Code No. 723 (US$ million, constant 1975 prices).

Importers	N I C/Group A				Other Developing (B+C)				U S A				Other OECD				W o r l d			
Year Exporters	1970	75	80	83	70	75	80	83	70	75	80	83	70	75	80	83	70	75	80	83
N I C/ Group A	2 3% 15%	4 2% 5%	8 3% 2%	13 5% 4%	9 2% 69%	52 5% 68%	95 6% 39%	44 4% 15%	- - 0%	2 3% 3%	121 51% 50%	234 60% 79%	1 0% 8%	5 1% 7%	3 0% 1%	3 0% 1%	13 1% -	76 3% -	241 6% -	298 10% -
U S A	15 22% 13%	34 17% 12%	65 27% 17%	151 52% 30%	29 8% 25%	106 10% 38%	128 7% 34%	128 12% 25%	- - 0%	- - 0%	- - 0%	- - 0%	68 13% 58%	130 15% 47%	172 12% 46%	213 18% 42%	118 10% -	278 11% -	374 9% -	506 16% -
Japan	25 36% 16%	57 28% 19%	108 45% 17%	93 32% 15%	63 17% 40%	172 16% 57%	450 26% 70%	426 38% 69%	51 34% 32%	25 31% 8%	26 11% 4%	42 11% 7%	14 3% 9%	34 4% 11%	40 3% 6%	53 5% 9%	159 13% -	300 11% -	639 16% -	620 20% -
Other OECD	24 35% 3%	105 51% 6%	53 22% 2%	24 8% 1%	250 67% 28%	692 63% 38%	960 56% 38%	505 45% 31%	96 64% 11%	51 64% 3%	74 31% 3%	98 25% 6%	408 80% 46%	696 78% 38%	1193 82% 47%	877 75% 54%	884 73% -	1817 69% -	2551 63% -	1624 52% -
World	69 - 6%	205 - 8%	238 - 6%	288 - 9%	374 - 31%	1093 - 41%	1723 - 43%	1110 - 36%	150 - 12%	80 - 3%	237 - 6%	392 - 13%	507 - 42%	888 - 34%	1453 - 36%	1168 - 38%	1217 - -	2643 - -	4049 - -	3103 - -