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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

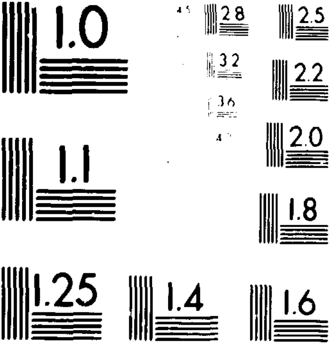

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TABLE OF CONTENTS

Pages

1. INTRODUCTION

1.1. Background

The energy sector in most countries of the world underwent a drastic transformation during the nineteen Seventies. The impact of this transformation is triggering changes in the magnitude as well as the composition of capital goods required for energy development. (The term "capital goods" in this paper implies equipment necessary to set up new energy facilities* or to complement existing ones. These include a wide variety of goods such as power machinery like turbines, generators, boilers, switch gears, insulating cables and fossil fuel related equipment such as oil rigs, liquid pumps, gas pipes, coal mining and handling machinery such as excavators, cranes etc.) These transformations in the demand for energy capital goods are of concern to the North as well as to the South and within the South, to the oil importing as well as to the oil exporting countries. For the South, the production and trade of oil and oil products is a much discussed issue, but not enough attention is given to the manufacturing and trade of capital goods for energy development. It is interesting to contrast the imports of oil and imports of capital goods further because they each not only compete for foreign exchange but are partial substitutes for each other. That is, with more capital goods it may be possible to partially reduce oil imports. While oil and oil products are required for servicing existing machinery and capital stock and hence for running the economy, the capital goods for energy are required to generate new capacity to produce more energy for building up the economy. The South in particular requires foreign exchange of a comparable magnitude for both of these. For example, in 1979 the South's crude oil import bill totalled US-$28 billion whereas imports of capital goods amounted to about US-$20 billion**. Moreover, in

* The term energy facilities or energy supply industries includes power plants (and their distribution), refineries, oil wells, coal mines, and also wind mills, bio-gas plants etc.

** Both of these figures refer to imports (and not net imports in which one subtracts exports) and include all developing countries. The share of Mid-East, which is an oil exporter, is 20% in the imports of capital goods. It should also be noted that the purchase of such capital goods is investment, whereas purchase of oil is considered budgetary expenditure which has to be made every year.

the case of imports of capital goods, depending on the country, nearly 30% to 90% additional investment occurs in local currencies. In the same year, the South claimed 12% of total world imports of crude oil, but it had 30% to 60% (depending upon the equipment) of the share of world imports for capital goods for energy. This means that the oil-importing developing countries of the South are doubly dependent on imports for their energy needs, on the OPEC countries as well as on the North for crude oil and refined petroleum products and mainly on the North for capital goods for energy.

Subsequent to the two major oil-price rises in 1973 and in 1979, considerable adjustments have taken place in the energy consumption patterns of the North as well as the South (see Table 1). This has naturally affected energy sector development plans significantly, and consequently the requirements for capital goods. In the North, energy consumption growth rates fell drastically, even leading at times to a reduction in energy consumption in absolute terms. This means that the North no longer requires capital goods to the extent of its capacity to produce them. Some of the capacity for capital goods manufacturing was set up in the North in the late sixties and early seventies on the assumption that traditional energy growth rates (typically 3% to 5%) would prevail. Even after 1973, many energy analysts expected that although oil consumption may decline, electricity consumption growth rates in the North will not be significantly affected and may even increase. By 1983, even the electricity growth rates fell substantially compared to past trends in most of the OECD countries. This, of course, exerts a direct impact on the North's demand for new capital goods for energy development. Even though some observers expect energy demand to increase following an economic recovery, there may be a time lag before capital goods demand for fresh energy development projects picks up, and even then it may not reach previous growth rates. In the South, energy consumption growth rates are much higher compared to the North and the South will require a larger proportion of these capital goods. Thus, the nature of the North-South flow of capital goods may require a new orientation.

In order to reduce their imports of capital goods, some developing countries are increasing their capability to manufacture those items domestically which require low or medium levels* of technological inputs. However, such decisions must be made carefully by considering a variety of factors such as availability of infrastructure and raw materials, domestic demand, costs of domestic manufacture and equivalent import prices. All of these factors have to be considered from a long-term perspective. For those developing countries where the technological feasibility of manufacture is uncertain, a cost-benefit analysis bears less relevance. For the purpose of identifying technological feasibility, a broad technological classification of the capital goods is relevant. e.g. in terms of high, medium and low technological requirements. Similarly,the scope of demand is equally important, as it differs from country to country.

Within this framework, the present paper aims to identify factors behind increasing either the manufacturing base or imports of capital goods for energy development. It further attempts to indicate some of the structural changes in trade and their implications for North-South and South-South co-operation by classifying the countries of the South into different categories.

1.2. Scope of the paper

In the following section, trends of energy, oil and electricity consumption and production for the world and North and South are reviewed with particular reference to the years of 1973 and 1979 which each mark sudden rises in the price of oil. The shares of each of these country groups in the world total is also noted. It is shown that capital goods for power development dominate the total energy sector, even though direct use of fossil fuels may provide a large share of energy. The reasons for this are discussed. Trends for imports, exports and the manufacture of capital goods are also examined.

In Section 3. a methodology to group a large number of countries and commodities is suggested which reveals certain trends and patterns, clarifying the policies from which each country group may benefit. In particular, technological feasibility emerges as the key constraint in the domestic

* That is, excluding "high technology" items. This is better defined in Section 3.

manufacture of capital goods. In this way, a few indicators which characterize technology levels of various commodities are identified.

In Section 4, some additional constraints on domestic production are discussed, such as raw material availability, engineering services required to construct energy facilities from capital goods, and special problems related to new and renewable energy resources. The highlights and policy implications discussed in the concluding section point to the changes required in North-South co-operation and indicate further areas for South-South co-operation.

2. RECENT TRENDS IN ENERGY CONSUMPTION PATTERNS AND IMPORTS OF CAPITAL GOODS: AN OVERVIEW AT WORLD REGIONAL LEVEL

2.1. Energy Consumption Patterns

Although the subject of this paper focuses on questions related to energy supply rather than demand, a short discussion of the structural changes that recently took place in demand patterns is essential for an estimation of required capital goods.

In particular, the most relevant indicators include recent changes in the production and consumption growth rates of energy as a whole and its two important elements, oil and electricity, as well as changes in the overall energy mix.

In this section, the relative importance of capital goods for fossil fuels and power generation is also discussed in order to set the stage for more specific discussions in subsequent sections.

2.1.1. Structural changes in energy consumption patterns and their implications

Two major changes took place after the rise of oil prices in 1973:

a) A reduction in energy consumption growth rates; and

b) changes in the energy mix, i.e. reduced shares of oil.

The most important change which has occurred and continues to evolve is the reduction in growth rates from their previous overriding trends. During the fifties and sixties, growth rates increased compared to previous decades, while in the seventies,especially after 1973, the growth rates have decreased. Some recent statistics regarding this phenomenon are summarized in Table 1 and Table 2. The changes that took place after the 1979 price-rise are of special interest. During 1979-81, there were negative growth rates for energy and oil consumption as well as production at the world level. Surprisingly, this is true even for the developing countries (for the world as a whole) except for total energy consumption.

Table 1. Commercial energy and oil production and consumption. Average annual growth rates, percent per year.

Groups of Countries		Production		Consumption		
		Comm. Energy	Oil	Comm. Energy	Oil	Electricity
Developed Market Economies*	1965-73	2.85	3.71	4.43	6.53	7.3
	1973-79	1.29	0.96	1.12	0.40	3.4
Centrally Planned Economies**	1965-73	4.16	10.16	4.41	7.90	7.4
	1973-79	5.27	6.16	4.881	5.15	6.5
Developing Market Economies***	1965-73	9.67	9.97	7.84	8.00	10.3
	1973-79	1.46	0.93	5.85	5.89	9.0
	1979-81	-6.41	-10.41	3.01	2.19	5.6
World	1965-73	5.44	7.89	4.61	6.92	7.6
	1973-79	2.55	1.95	2.69	2.04	4.6
	1979-81	-1.87	-5.30	-0.93	-4.04	2.4

Data Source: Yearbook of World Energy Statistics (1974),(1979), and (1981), United Nations.

* Market Economies: including countries of North America, Western Europe, Japan and Oceania.

** Including countries of Eastern Europe, USSR, P.R. of China and East Asia.

*** Developing market economies of Asia, Africa and Latin America.

There has been a change in the reporting system of the energy statistics in 1981 and the subtotals for each group of countries is not readily available. The author has done this only for the developing countries. There may be slight inconsistencies with the previous years due to differences in the coverage of small countries. This may have effects on growth rates of 1979-81 and also due to the fact that the figures for 1979 as reported in the 1981 Yearbook are different compared to those reported in the 1979 Yearbook.

Table 1 shows the total energy consumption growth rate for world energy demand which was 4.61% during 1965-73, fell to -0.93% during the 1979-81 period. The growth rate for developing countries during the 1979-81 period was 6.60% as compared to 7.84% in 1965-73. The growth rates for oil consumption relative to the growth rates of total commercial energy consumption for all groups of economies fell during the post-1973 period. For the developing market economies, oil consumption growth rates were reduced from 8.0% over 1965-73 to 2.2% over 1979-81. This means that the shares of other energy sources, such as coal, gas, and hydro power are correspondingly higher. Table 2 shows that the developing countries' consumption share in the world total has increased from 7.5% to 12.3% for energy and 11.6% to 18.6% for oil during the 1965-1981 period. The growth rates for electricity consumption, which is the most capital intensive energy source but is versatile in terms of applications and the variety of primary energy forms used for its production, also declined continually over time. The developing countries still had the higher growth rate for electricity during 1979-81 as compared to other groups of countries or as compared to energy as a whole.

Table 2. Distribution of world production and consumption of commercial energy and oil up to 1981 (as percentages).

		Production		Consumption	
		Comm.En.	Oil	Comm.En.	Oil
Developed	1965	46.19	46.19	31.81	62.81
Market	1973	38.62	23.02	62.37	70.43
Economies	1979	35.85	21.71	56.86	63.92
Centrally	1965	29.90	17.18	29.72	15.34
Planned	1973	28.27	17.41	28.78	16.67
Economies	1979	33.08	22.21	32.53	19.96
Developing	1965	23.90	51.00	7.46	11.56
Market	1973	33.10	59.52	8.83	12.90
Economies	1979	31.03	56.05	10.59	16.09
	1981	28.22	50.17	12.28	18.63
World		100	100	100	100

The percentages may not all add to 100 because of rounding. See footnote of Table 1 for grouping of countries.

Calculated from: Yearbook of World Energy Statistics (1979), United Nations.

Tables 1 and 2 together suggest that the sudden reduction in energy consumption growth rates could have led to underutilized capacity for the manufacture of capital goods located primarily in the North, which may benefit the South by shifting there. What are the implications of reduced consumption and changes in the energy mix for the capital goods sector ? What is the relative importance of primary energy from fossil fuels vs. secondary energy from power generation ?

2.2. Trends in Capital Goods Requirements for Energy Sector for the Developing Countries

2.2.1 Primary energy extraction of fossil fuels

Even though fossil fuels comprise more than 80% of total energy consumption,the input of capital goods for their extraction is not large.* Of course, countries which plan to mine their own fossil fuels would require capital goods for exploration and development but these needs are relatively small compared to the power industries need for capital goods. This is reflected in the loans given for different energy projects. For example, the World Bank-- in spite of its strong emphasis on petroleum exploration-- disbursed 75% of its loans in 1980 for the power sector, with the remaining 25% given for coal, oil and gas development. It is difficult to obtain separate statistics for the capital goods requirements of fossil fuels. For example, equipment for fossil fuels, such as shafts, cranes, liquid pumps, dewatering equipment etc. are often aggregated with other equipment for construction and mining and are not separate categories in either trade or industrial statistics. Much of this equipment is also used by the building construction industries as well as mining industries and no separate statistics to indicate what portion is used for coal, oil and gas development exclusively are available. Furthermore, capital goods are not widely used for coal in the developing countries because significant coal resources are located in only a few countries, such as India, China and Botswana. Moreover, India and China are capable of producing some capital goods themselves.

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* For example, none of the capital goods related to fossil fuel development are more than 5 digit items in the trade statistics. The capital goods for power industries on the other hand, are spread into four separate items at 3 digit level.

It was previously shown that the share of oil consumption in the energy sector is gradually decreasing. However, higher oil prices had led to increased oil and gas exploration in many countries. A look at the itemized contents of oil and gas exploration projects suggests that technical services, consultations, seismic surveys, geological surveys, labour costs, etc. take up a large percentage of the project, while the share of capital goods is less important. Very often the equipment for exploration is leased for short periods by the firms carrying out the contracts.

Thus, primarily due to the fact that it is difficult to obtain separate statistics and that they do not constitute large shares of total capital goods required for the energy sectors, capital goods requirements for fossil fuels are dealt with in less detail. However, some fossil fuels are used directly and some are processed to obtain secondary energy from conversion or processing facilities, such as power plants, refineries, coal washeries, etc. The capital requirements for such secondary conversion and processing actually dominate the total energy sector. To this we will give greater attention.

2.2.2. Secondary energy production: power plants and refineries

Interestingly, even though electricity constitutes no more than 10% to 20% of total energy, it claims a large share of capital and capital goods requirements for the energy sector. Between 1980-85, Bangladesh plans to spend 14.5% of their development expenditures on energy, of which 69% will go for electricity. In Kenya, 10.5% of its capital formation in 1983 will be in the energy sector, most of which will go to the power sector. In India (sixth five-year plan 1980-85), 27% of the sixth plan expenditure will go to the energy sector, and of that 70% will go into the power sector. The desirability of such predominance of the power sector in energy plans has been questioned recently and developing countries have been encouraged to invest in new and renewable energy resources. This will no doubt be a welcome change if projects with feasibility studies are prepared urgently. However, the predominance of the power sector in the outlays of the developing countries is due to the following major reasons:

(i) The power sector is in the early stages of development, as shown by the low per capita electricity generation that one finds in the developing countries.

(ii) Since payments for oil could be regarded as annual expenditures, the electricity sector remains a priority item in investment plans unless a country has major indigenous resource development programs for coal, oil, or gas. This is why in Kenya (1980) the share of electricity in the energy development plan is nearly 100%.

(iii) Power plants have high capital output ratios and even countries like India, which have plans to develop coal mines and oil wells, spend 70% of their planned energy investments in the power sector (Government of India, 1981).

(iv) Electricity is difficult and expensive to import over long distances and excepting a few, most developing countries do not have surplus power to export to neighbouring countries. Thus, unlike oil, it is not traded in large quantities and must be domestically produced. Besides, transporting electricity through transmission and distribution networks involves significant investment exclusively for that purpose. On the other hand, a part of the transport network for fossil fuels (roads, railways) could be used by non-energy sectors of the economy as well.

(v) Natural endowments of primary sources within a country (e.g. oil in the OPEC countries or natural gas in Bangladesh) represent a gift of nature rather than a level of industrial development. But the existence of large power generating capacity invariably indicates a large (other) industrial base. Lack of fossil fuels does not imply lack of industrialization (e.g. Japan) but lack of electricity producing capacity does.

The growth of the power sector has decreased from 10% in Africa and the Far East and 14% in Latin America in the sixties to 8% and 10% in the seventies, respectively. In spite of high oil prices, high growth of electricity (of about 6%) is expected to continue in the eighties for the following reasons:

- Electricity substitutes for human and animal labour, reducing drudgery, increasing efficiency in production and improving the quality of the products;
- Electricity, particularly when generated from locally available coal, gas, or hydro, could be a substitute for oil in:

- the household sector for kerosene used in lighting and cooking;
- the agricultural sector for diesel used in irrigation pumps, tubewells and food processing;
- the industrial sector for fuel, oil and diesel oil;
- the transport sector for diesel for railways and service vehicles;
- the commercial sector for kerosene and diesel used for lighting, petromax or diesel generators for electricity.

On the other hand, more than 60% of the electricity in the developing countries is consumed in the industrial sector, where there is considerable room for conservation. There are indications that some progress in conservation has been made in some developing countries, e.g. Parikh J. (1981), Parikh J. and Chaitanya A. (1980), Jankowski J. (1980).

Similarly, refineries also play an important role in secondary energy production by extracting usable oil products from crude oil. This is why the number of developing countries with refineries is larger than countries with indigenous crude oil supply. But refineries do not require as much investment as power and therefore, although they are important in managing oil products supply, their importance in energy investments is small (typically 3% to 13% , depending on the share of oil in the energy sector for non-OPEC countries)

2.3. Current Imports of Capital Goods

Table 3 shows that, in 1978 the shares of the developing countries in the world market were 65% for steam boilers, 47% for gas turbines, 50% for insulated wires, etc. Thus, the imports of only a few items add up to US-$12 billion.

This list does not cover any of the items imported for coal, oil and gas production and even excludes a number of items required for power plants. Annex A shows a fairly comprehensive coverage of items required for thermal power plants. Undoubtedly, the items quoted in Table 3 are the most expensive ones. Moreover, as mentioned before, some of the additional items are not exclusively used for the energy sector alone. They are also used for mining, Tabie 3. Shares of developing countries in the world market for imports of power related equipment * (1978)**

	SITC No.	Total in US-$M	Dvlpg. Countr. %	Africa Dvlpg. %	America Dvlpg. %	Mid East %	Far East %
Steam Boilers*	7111	665	64.7	10.1	11.6	27.0	15.8
Steam Trubines*	7113	346	34.5	1.5	9.1	16.5	7.3
Gas Turbines*	7116	438	46.6	11.7	11.9	21.2	5.6
Electric Power Machinery	7221	4205	50.4	10.7	10.8	18.6	10.2
Switch Gears	7222	3358	36.7	7.3	6.9	13.2	9.2
Insulated Wires	7231	1805	56.1	12.7	4.2	29.1	10.0
Electic Measuring Control Equipment	7295	930	19.4	3.4	5.9	5.7	4.4
Electric Condensers and Transformers	72995	271	22.3	0.6	5.2	2.1	14.4
Total		12018					

Source: Yearbook of International Trade Statistics, United Nations (1979).

* Major fractions of the equipment is likely to be used by power industries but some of it could be also used by other industries. On the other hand, the list given does not include all possible items required by power industries.

** There appear to have been reorganizations in the trade statistics in the year 1980, so that some of the commodity groups coverage is different.

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other industries and construction purposes and separate statistics for how much is used for the energy sector are difficult to obtain either in the UN or national statistics. From available project costs and other evidence, it seem reasonable to assume that the remaining items such as transformers, compressors, liquid pumps, ash handling equipment, crushers etc. for power and excavating machinery, cranes, pipes, drilling rigs, etc. for coal, oil, and gas can easily increase the sum by at least another 50% to 60%, bringing the total to $18 to $20 billion. One can also make a quick check with the World Bank estimate (1981) of investments in the energy sector which puts the figure at $34 billion in 1980 with a foreign exchange component of 60% to 65%. This gives an import figure of $20 to $24 billion.

A few countries also export some items but this is at a low level as discussed in the next section.

3. REGROUPING OF COMMODITIES AND COUNTRY GROUPS

When one considers an issue that covers a large number of commodities and more than 100 countries, a conceptual framework for aggregation and grouping is necessary. Without this it may be difficult to formulate the problem and suggest policy prescriptions.

This section develops classification principles of technologies for different commodities and a country grouping methodology.

3.1. Classification of Equipment into Levels of Technologies

As shown in Annex 1, the list of equipment is so large that some principle of aggregation is required. This aggregation allows for convenience and clarifies the issues. It need not be considered rigid and may vary with the specific issues being addressed. Here, several indicators together or separately have to be checked before classifying equipment into high, medium or low technology items. These indicators are discussed below:

(a) Size and scale of the item:

This factor is crucial for manufacturing certain items, such as 50MW or 500MW power plant or 33kV or 400kV transmission lines. The former may be easier to manufacture than the latter.

(b) Demand of units of 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, development of that technology becomes economically attractive. Sometimes that makes it possible for a number of manufacturers to make the same products, e.g. in the case of insulated wires.

(c) Precision and skills required for manufacturing:

Some large size and even some small size items may require highly technical precision and therefore specific skills and infrastructure which may not be available, e.g. large generators or controlling and measuring equipment.

It is reasonable to assume that decision-making for domestic manufacturing vs. imports would have to balance the above three indicators. Of course, there are other factors as well which would have to be balanced, such as relative factor costs of inputs, international prices, opportunity costs of investments to be made, relative advantages etc., but these do not relate to classification of technologies. Skills, infrastructure, critical size and the demand levels are usually overriding factors which determine the prima facie feasibility of domestic manufacture in a reasonable time compared to factors such as labour intensities or current prices which are subject to major revisions and which mainly affect the economic evaluation. It therefore seems reasonable to talk first about the feasibility of manufacturing capital goods for energy development. This basis is especially suited for capital goods industries for the power sector. Based on these indicators the following classification principles are evolved.

The classification relates only to energy industries and does not refer to other industries. Moreover, it offers only a general demarcation and would undoubtedly have exceptions depending on the particular situation. The classification is expected to show broad patterns.

3.1.1. High technology terms

These are often large size equipment which may require sophisticated skills and precision in manufacturing. Sometimes they are not needed in large number and therefore there are only a few manufacturers; often only one in a country, if any (Surrey, J. 1983). They include large items like turbines, generators, boilers, or precision items such as controlling equipment, etc. They relate in particular to large scale power generation and distribution, off-shore oil exploration, deep coal mines etc. Occasionally they are used for specific locations and situations which are difficult.

3.1.2. Medium technology items

Transformers, compressors, liquid pumps, etc., are considered medium technology items. They are demanded in a large number and could often be manufactured by several manufacturers. They do require precision and skills but not of especially high order. Some are also needed by industries other than the energy industries leading to moderate size demand.

3.1.3. Low technology items

These refer to items like insulating cables, fuses, valves, etc., required in large quantities which could also be made in the unorganized sector. They require relatively low level skills and could use semi-skilled persons but this may still be high for the rural areas of the developing countries.

It should be stressed again that some items such as insulating cables or transformers may need high or medium technology if one is talking about high voltage transmission. Thus, without labelling them in detail, such classification could not be precise. But for discussion purposes this classification suffices.

3.2. Groups in the Countries of the South

In general. the reference to "South" in the literature, encompasses more than 100 countries of very diverse nature. Sometimes they are further classified by some of the UN agencies in terms of world regions, such as Africa, Asia and Latin America. On the other hand, the World Bank classifies them in terms of low, middle and high income groups.

More efforts have been made in disaggregating them into OPEC and non-OPEC countries, where the latter group is further classified into oil importing countries (OIDCs) and non-oil importing countries (Malaysia, etc.).

Efforts have also been made to classify them according to energy resource availabilities. However, energy resources are not the only resources required for industrial development and then one has to go into mineral availability and so on.

Therefore, none of the above classifications are entirely suitable for understanding how to increase manufacturing capabilities. This requires a classification system which considers critical size needed for developing domestic manufacturing capabilities.

The following classification of countries is suggested which seems to be appropriate. The basis of such classification for each group of the South is discussed below. A full list of all countries along with other data is given at the end of the paper.

The discussions concerning country classifications go hand in hand with technology groupings which were discussed previously.

South 1. and China: This group consists of countries presently engaged in manufacturing equipment requiring skills and equipment of somewhat large-scale nature. Thus, it includes countries with large industrial bases such as South Korea, and on the other hand large countries, such as China, India, Mexico, Brazil, Argentina. Their attributes are as follows. Their annual energy consumption is at least 30 million tons of oil equivalent (30 mtoe) and annual increments of the order of 1000MW for the power capacity. Part of their demand, either due to large size (India) or to high income(Venezuela) or both (Mexico) is for large scale equipment, such as 200 MW to 800 MW turbines, 400 kV transmission lines, etc. They can import directly what the North has to offer. On the other hand, some of them have already achieved some degree of ability to manufacture medium scale items such as switch gears, transmission towers, etc. and much of the equipment necessary for 100 MW to

300 MW plants, including high technology items. In fact, some countries already export to other developing countries, e.g. equipment for 50 MW to 100 MW power plants, or could be expected to compete in the future in exporting this equipment. But this proceeds on a very small scale, as some of them, at present, could barely keep up with their own demand targets. Note that India, which is a low-income country is included along with Brazil and Mexico and other high-income countries, simply because it has a large demand base (more than 3000 MW addition in a year) making it possible to go into indigenous manufacturing. On the other hand, Pakistan, which also has skilled manpower but whose annual demand increment is low (800 MW split into several units) may not find it worthwhile to invest in developing indigenous capacity for all types of power equipment.

Thus, the trade of North-South 1 would be restricted in nature involving only some high technology items. Nevertheless, it would be the most favourable due to large demand and a scale which is compatible with the North; for example, large size units greater than 500 MW typically used in the developed countries. The names of the countries are given in Annex B along with their attributes relating to the energy sector.

South 2. Having already explained the logic behind the South 1 groups, it is sufficient to say that South 2 consists of those countries which are or could be engaged in using and manufacturing medium and low technology items. They would generally import capital goods from the North, and although their requirements are small individually they collectively reach a reasonably large scale. They could import some capital goods from South 1 group of countries, as and when South 1 would have excess capacity beyond their own requirements.

This group includes medium-sized countries ranging from Colombia, Peru, Pakistan, Indonesia, Malaysia, etc. Their populations, barring a few exceptions, range from 10 million to 120 million. During the period 1970-79, most of these countries added power capacity of 2500 MW and more.

South 3: This consists of numerous small countries who may not find it worthwhile to manufacture high and in some cases even medium and low technology items. Some countries of this group, such as the least developed countries, may even find it difficult to maintain the power systems due to lack of spare parts and skilled personnel. They may require assistance from the North and South, financial as well as technical assistance for power system planning. Their annual demand occupies the 1 MW to 50 MW range and sometimes goes below the kilowatt range of the 500 MW standard unit size in which the countries of the North specialize. Most of the countries of this category added less than 250 MW during the 9-year period 1970-1979. Thus, they do not make interesting clients for the North strictly for trade reasons.

Of course, no amount of disaggregation suffices because the diversity between countries in any group will persist. But some degree of compromise is necessary to simplify the matter. For example, one could ask to make a separate category for the least developed countries (LDC) in South 3 along with other small countries who are preoccupied with other types of manufacturing. Note that the classification had to be based on absolute rather than per capita level of power capacity or energy consumption in order to address the issues raised in this paper. Secondly, there will always be border-line countries which could be in the neighbouring group depending upon the chosen cut-off point. Exceptions had to be made in the case of Egypt, which is put into category 2 rather than 3 in spite of nearly zero increment of capacity during 1970-1979, and several other countries. Inclusion of Bangladesh in South 2 rather than South 3 in spite of its being the least developed country is not surprising considering the large population, availability of skilled persons and its small but not negligible manufacturing base. Even the OPEC countries had to be split into different groups depending upon the size of demand and available industrial infrastructure.

3.3. Insights due to Reclassification of Country Groups and Equipment

How does the reclassified picture differ from that presented in Section 2 in world regional terms ? What additional insights are obtained from it ? This is discussed in three ways:

- in terms of energy consumption and capacity for electricity production
- in terms of imports of capital goods
- in terms of manufacturing capital goods.

South 1, South 2 and South 3 represent 7, 29 and 92 countries and have 59%, 27% and 14% of the population of developing countries, respectively. The country-wise details are given in Annex 2.

3.3.1. Energy consumption and capacity for electricity generation

Table 4 shows that energy consumption of South 1, South 2 and South 3 in 1981 was 739, 237 and 135 mtoe of primary energy. During the period 1970-1981, their growth rates were 6.2%, 6.7% and 6.0% respectively. The shares of each in the total energy consumption by developing regions are 66%, 24% 9% for South 1, South 2 and South 3, respectively. As regards the capacity for electricity generation, the shares of the three regions in the total capacity in the developing world in 1981 were 64%, 29% and 11%, respectively.

3.3.2. Imports of capital goods

The imports of capital goods have also different patterns for South 1, South 2 and South 3. These are illustrated in the tables given in Annex B. Since the countries of South 1 have their own industrial base, they do not import low and medium technology items in a big way, e.g. for power transmission and distribution is only 8% of the $3814 million spent on the four items. It appears that only Mexico imports them. Thus, among their imports power generating machinery have a much larger share. On the other hand, the countries of South 2 make an interesting case to study the rise in imports for oil vs. the imports for power industry and the price escalation in each. For making such a comparison over a 12-year period, data for Egypt and Chile— for which disaggregated data up to 1967 are available-- are tabulated in Tables 5 and 6. It is emphasized that only four major commodities for power are considered and that they represent only part of the total imports of capital goods for power industries.

Table 4. Population, energy consumption, its growth rate and power capacity in reorganized developing regions.

Country Groups	Number of countries[a] (10^6 toe)	Commercial Energy Consumption (%) 1970	1981	Growth Rate (GW)[a] 1970–81	Electricity Capacity 10^6 Kilowatt 10^6 1981	Population mid-81
South 1	7	380 (67%)	739 (67%)	6.2	197 (64%)	1955.7 (58.4%)
South 2	29	134 (24%)	276 (25%)	6.7	76 (29%)	914.9 (27.3%)
South 3	92	50 (9%)	952 (8%)	6.0	36 (11%)	477.6 (14.3%)
Total	128	564	1109	6.3	309	3348.2

[a]Worked out from the energy data given by the Yearbook of World Energy Statistics (1980) UN, and includes all countries.
Population statistics from the World Development Report (1983) World Bank and includes countries with population larger than one million only.
For the names of the countries included in each category see Annex 2.

South 1 includes countries with energy consumption of 30 mtoe per year and above and power capacity of about 10,000 MW and above. It includes Argentina, Brazil, China, India, Mexico, South Korea and Venezuela.

South 2 excludes those countries with population less than 5 million and those already included in South 1.

South 3 includes the remaining small countries.

Numbers in brackets are the shares of each country group in the total of all developing countries given at the bottom of the table.

Table 5. E G Y P T: Energy related imports data for petroleum and power. Weights, values and prices.

Commodity Name	SITC/ Technology Levels		1967	1976	1978
Crude	331	W*	2483	1281	0.707
Petroleum,		V	38306	108397	72
etc.		P	15.42	84.61	103
Petroleum		W*	176	227	94
Products	332	V	10345	23453	30843
		P	58.77	103.31	328.11
Total Petroleum		V	48651	131850	30915
Power		W	12693	7157	7795
Machinery	711	V	16793	27352	55602
Non-Elec.	High	P	1.32	3.82	7.13
Elec. PWR		W	7435	13501	19481
Machinery	722	V	16368	39748	130768
Switchgear	Medium	P	2.20	2.94	6.71
Electricity	723	W	4662	31654	44982
Distributing	Medium	V	3193	33500	103486
Machinery	and Low	P	0.74	1.05	2.30
Electrical	729	W	3847	33226	20178
Machinery	Low	V	6267	41574	74354
		P	1.62	1.25	3.68
Total Power Equipment		V	42621	142174	364210

Compiled from the Yearbook of International Trade Statistics

W = weight in 1000 tons; W* = weight in 10^6 tons; V= value in US-$1000; P = prices obtained simply by dividing value with weights and is only a crude measure (see text). Since the commodity is given with three-digit classification it comprises of several individual items and their composition may vary over the years. The idea is to show that prices increased by different factors between 1967 and 1978 according to the levels of technologies.

Table 6. C H I L E: Energy related imports data for petroleum and power. Weights, values and prices.

Commodity Name	SITC		1967	1975	1978
Crude Petroleum etc.	331	W*	2265	3321	3563
		V	42935	287787	378264
		P	18.95	86.65	106.16
Petroleum Products	332	W*	450	56	69
		V	13949	9017	17757
		P	30.99	161.01	257.34
Total Petroleum		V	56884	296804	396021
Power Machinery Non-Elec.	711 High	W	890	3915	4455
		V	1248	24766	34785
		P	1.40	6.32	7.80
Elec.PWR Machinery Switchgear	722 Medium	W	4826	4033	5028
		V	19691	36234	49910
		P	4.08	8.98	9.92
Electricity Distributing Machinery	723 Medium and Low	W	1293	1236	-
		V	2378	3913	-
		P	1.83	3.16	-
Electrical Machinery	729	W	4755	448	7569
		V	15610	29438	47402
		P	3.28	6.61	6.26
Total Power Equipment		V	38927	94351	132097

in millions
See footnotes of Table 5.

Egypt turned into a crude-oil producer during the 1967-1979 period. Therefore, in 1978 it imported refined petroleum products and also considerable amounts of high and medium technology items. The "prices"* of these commodities have also increased several-fold during this period and have increased about as much or more than crude-oil prices.

Eygpt's example may bear relevance for many countries who are turning into crude oil producers faster than they can manufacture capital goods for energy industries. For such countries, the ratio of values of imports for capital goods to the value of export of petroleum may increase because of changes in prices of capital goods. Such countries are Mexico, Malaysia, Sudan, Peru, etc.

Prices of imports: Egypt's and Chile's examples in Tables 5 and 6 show that the prices have increased five to six-fold during the period 1967-78 not only for crude oil but also for petroleum products and by a similar factor for high technology capital goods. On the other hand, for medium and low technology items, where there is more competition from other countries including developing countries, the prices have only increased by a factor of three and two respectively. Thus, empirical evidence suggests that the extent of increases for capital goods seem to be according to the levels of technology because of different competition for each level. Because the composition of imported items varies from year to year, the rise of prices of capital goods cannot be confirmed definitely from the data of one country. However, there are more examples in the UN trade statistics, which support such a hypothesis. In addition, one has indirect confirmation from the World Bank projections. One estimate made as recently as in 1980 (World Bank, 1980) was that annually US-$70 Billion (1980) prices would be required as investment in the energy sector in the eighties. However, recently this estimate was raised to US-$130 Billion (in 1982 prices) according to Rovani Y. and Rao D. (1983). Although

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* Throughout this discussion "prices" are obtained by dividing values with weights. As we have several items in a given category, this is merely an indicator.

country coverage and other factors may explain some of the differences, a separate study to look into the increases in prices of capital goods is called for.

3.3.3. Manufacturing capital goods for energy development

Unfortunately, the limited data available on this subject does not make it possible either to go into regrouped countries or to go into details of levels of technologies. In Table 7, available data is given for geographical world regions only. It can be seen that in the developing countries high technology items such as excavating machines and cranes which can be used in coal mines are made in a small number compared to the world production. On the other hand, medium technology items like compressors have a relatively larger share of the world production.

It should be stressed that part of the difficulty also lies in the inadequate coverage of developing countries. If the coverage is increased from actual country statistics, the shares of developing countries in the world production will go up (but not a great deal). For example, it is well known that China manufactures domestically much of what it needs but this information does not exist in the UN industrial statistics. India, as shown in Annex C, imports only 4% of its needs as far as power industries are concerned. But not all of it appears to be in the UN statistics. The rest is made domestically. In some countries, one indirect way is to look at imports. For example, Brazil, Venezuela and Argentina do not import power distributing machinery. However, manufacturing statistics do not document how much is made domestically. Thus, a comprehensive data base for manufacturing is necessary.

3.3.4. Exports of capital goods for energy

Exports for capital goods for energy from developing countries are indeed at a very low level. Table 8 indicates weights and values of some of the energy related exports for 1975 and 1978. As is to be expected, they are essentially from South 1 with Brazil leading and India trailing behind. Argentina and Mexico are small exporters too. Even South 1 countries

Table 7. Production of high and medium technology items related to energy indusrries by developing regions

Item/ISIC No.	Unit	Region	1971	1975	1980*
Excavating Machines 382425	no	Africa	13	9	9
		S. America	-	-	-
		Asia	-	103	-
		World	-		130528
Pumps for Liquids 382 942	10^3 no.	Africa	4	8	7
		S. America	125	174	251
		Asia	342	506	979
		World	-	-	35385
Compressors 382946	no.	S.America	41362	938561	*
		Asia	6811	51673	127571
		World	-	-	5289274
Cranes 382949	no.	Africa	-	1-5	-
		S.America	1043	..	-
		Asia	-	13622	-
		World	-	-	191049
Cables 381910	10^3t	Africa	20.4	23.9	22.2
		S. America	7.4	6.4	7.4
		Asia	38.7	52.6	85.0
		World	-	-	1102.4

Source: Yearbook of Industrial Statistics, Vol.II(1980), UN, New York.

Note: When data not available, see columns of 1975 for approximate production of developing regions.

Africa excludes South Africa.
Asia excludes Japan, USSR, China.
S. America excludes Mexico.
Note than these items are not used by energy industries exclusively.

Table 8. Exports by South 1 Countries of Selected Items Used for Energy Development.

Country	SITC Code No.	1977* Weight	1977* Value	1980* Weight	1980* Value
Argentina	711	6578	12937	4888	25550
	722	16[illegible]9	10284	1641	15345
	729	892	9747	3059	20427
Brazil	711	42075	109563	86027	341619
	722	5375	37006	11836	66933
	729	5037	62769	13828	139306
India	711	-	34697	-	66975
	722	-	21016	-	39133
	723	-	21170	-	21277
	729	-	14948	-	28728
Mexico	711	-	17796	48157	57686
	722	-	12922	-	13440*
	723	3493	6667	19538	90048
	729	-	39578	-	-
Korea Rep.	71	-	26338	-	92150
	72	-	35816	-	67994

Compiled from UN (1980) International Trade Statistics.

* The exact corresponding years are different for different countries, e.g.

Argentina	1975	and 1978
Brazil	1976	and 1980
India	1975	and 1978

Statistics for Korea Republic available at two digit levels including items other than energy capital goods.

like Venezuela and South Korea do not export capital goods for energy industries.

There are also a few of South 2 countries contributing at an even smaller level but notable among them are Hong Kong, Singapore, Taiwan (newly industrialized developing countries -NIDC), Malaysia and Colombia.

Among the items exported are mainly electric generating and distributing equipment but small amounts of controlling and measuring equipment are also exported by Brazil and India. Argentina exports lifting and handling equipment, some of which presumably could be used in coal mines and power plants. However, in terms of weights Argentina's exports have declined in 1978 compared to 1975.

It should however be stressed that each of the above countries also import the items belonging to the same general categories (at three digit level) as shown in Annex B. Their imports are several-fold greater than their exports, especially in the case of Argentina and Mexico. Most of these countries are net importers at the three-digit level. This is also true of China, India and Brazil but to a much lesser extent.

4. ADDITIONAL FACTORS FOR MANUFACTURING CAPITAL GOODS FOR ENERGY DEVELOPMENT

Development of capital goods industries for energy needs to be considered in a much broader framework which also includes other factors, such as requirements of engineering services and availability of raw materials. Moreover, as and when unconventional energy resources are developed, such as windmills, solar equipment, bio-gas generators, etc., a new appraoch will be required for manufacturing capital goods and for energy development in general. These aspects are discussed in this section.

In addition, issues related to the requirements of specific country groups need to be addressed. For example, the need of OPEC countries to develop oil and gas exploration production, refining and transport. However, due to their unique nature, it might be best done in a study devoted to that group alone.

4.1 Engineering Services for Energy Development

Once the capital goods are manufactured or imported, the energy facilities need to be constructed for which engineering services are required. They are varied and extensive in nature. They often require skills which are not available in the developing countries. They are required at three stages:

(i) Prior to commissioning a facility: These include services for geological and seismic surveys for all energy facilities including hydro, coal, oil and gas-- but, of course, of different types for each. Fossil fuel exploration often requires skills and contracts, for these are sometimes given to foreign consultant firms even by countries of South 1, and of course, in some cases, equipment required is not necessarily purchased but obtained on loan. Thus, in the case of exploration, reliable services for locating and siting are as important as the equipment. While local services could be helpful, their contribution is small in this case, especially in the countries of South 2 where foreign help is often necessary.

(ii) Constructing a facility: These require services for which partial use of local services could be made, especially for contructing buildings, dams, making roads, laying railway lines to move coal or digging for laying pipelines. The components of local labour could be more than 50% of the total services required. In addition to unskilled labour, this also requires skilled services and supervision. However, the countries of South 1 are able to obtain most of these skilled services domestically, except for occasional help for solving some exceptionally difficult problems. The countries of South 2 often need to work together with countries from which technologies are imported. The countries of South 3 are totally dependent on acquiring turn-key projects. For complex large scale projects such as nuclear power plants, even South 1 may require help.

(iii) Maintaining facilities: Maintaining energy facilities, such as thermal, nuclear or hydro power plants and transmission and distribution services, refineries, coal mines, oil wells and gas production and distribution, etc., requires skilled services as well as some routine work. Moreover, spare parts could require as much as 10% to 25% of the total expenses for capital goods for energy industries. Except for some occasional help from abroad for special problems, South 1 and South 2 are able to find the manpower required for maintaining energy facilities domestically. This is not the case for many countries of South 3 and especially the least developed countries.

4.2. Raw Materials and Inputs for Energy Industries

It is worthwhile to consider which raw materials are required for manufacturing equipment for the energy industries. This will help in analyzing the import vs. manufacturing issues with respect to energy industries and raw materials. The major raw materials required are iron and steel, cement (and concrete), copper and aluminium. Of course, steel could be of various types; carbon steel, stainless steel, low steel alloy, etc., each of which requires different levels of technological development. In Tables 9A and 9B, the data reported by Bechtel Corporation for constructing some of the energy facilities are analyzed and scaled for appropriate energy production of similar kind (oil, coal or power). However, scaling is not done, for example, for equivalent oil and power production. It can be seen that dam 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 of materials for oil and gas based power plants are the smallest followed by those needed by coal. Geothermal power, on the other hand, requires more steel but not much cement.

Amongst oil industries, the on-shore recovery to install 1 mbpd capacity on average requires 5130 tons of steel and 14380 tons of concrete which are higher than the requirements for off-shore oil. The same capacity refinery, on the other hand, requires only 250 tons of steel and

Table 9A. Material requirements in 10^3 tons for energy facilities: Fuels.

Facility Name	Unit	Carbon Steel	Low Steel Alloy	Stainless Steel	Total Steel	Copper	Aluminium	Concrete	Cast Iron
Oil and Natural Gas:									
1. On-shore Primary Oil Recovery	lmbpd	4.71	0.42	0.006	5.13	0.0136	0.003	14.38	0.048
2. Off-shore Oil Recovery Lower 48	lmbpd	2.40	0.16	0.004	2.57	0.008	0.007	1.6	0.025
3. Low-Gasoline Refinery	lmbpd effect	0.22	0.92	0.014	0.25	0.010	2.58	0.76	0.016
4. On-shore Oil Import	lmbpd	0.05	0.	0.	0.047	0.0001	0.	0.02	0.00055
5. LNH Import	1000 Mmcfd	35.35	3.	5.	44.35	0.34	0.114	175.	0.406
6. Natural Gas Stockpile	1000 Mmcf	0.39	0.015	0.001	0.406	0.001	0.0004	0.031	0.005
Coal:									
7. Underground Eastern Coal Mine	100 Mmtpy	407.	12.35	0.65	420.	7.25	2.55	765.	12.5
8. Surface Eastern Coal Mine	100 Mmtpy	435.	36.25	1.9	473.15	10.3	2.175	350.	34.
Nuclear Fuel:									
9. Surface Uranium Mine	1000 tpd ore	1.137	0.078	0.003	1.216	0.017	0.006	0.008	0.077
10. Uranium Mill	1000 tpd ore	0.966	0.015	0.002	0.983	0.017	0.037	6.	0.028
11. Uranium Conversion	1000 tpy	0.66	0.056	0.027	0.743	0.018	0.005	41.5	0.016
12. LWR Fuel Fabrication No Pu Recycle	1000 MTU/y	3.5	0.48	027	4.25	0.328	0.139	43.68	0.28

Source: Bechtel Corporation, USA, (1976)

Table 9B. Material requirements in 10^3 tons for 100 MW power plants.

Facility Name	Unit	Carbon Steel	Low Steel Alloy	Stainless Steel	Total Steel	Copper	Aluminium	Concrete	Cast Iron
Power.									
13. Oil-Fired Power Plant	100MWe	1.76	0.138	0.044	1.942	0.064	0.015	10.7	0.03
14. Coal-Fired Power Plant-Low Btu	100MWe	2.6	0.18	0.044	2.824	0.13	0.03	17.5	0.05
15. Low/Intermediate Btu Gas-Fired Plant	100MWe	0.9	0.087	0.02	1.	0.048	0.01	6.26	0.02
16. Gas Turbine Power Pl.	100MWe	0.3	0.022	0.006	0.5	0.021	0.005	1.57	0.01
17. Light Water Reactor	100MWe	4.3	0.43	0.182	5.	0.207	0.06	50.76	0.08
18. Dam and Hydro-electr. Power Plant	100MWe	5.8	0.144	0.017	6.	0.138	0.34	75.	0.23
19. Pumped Storage	100MWe	4.1	0.071	0.01	4.18	0.07	0.016	58.8	0.005
20. Geothermal Power Complex	100MWe	6.3	1.	0.36	7.66	0.25	0.067	5.5	0.313

Note: The compiling and scaling data was done by the author from the same basic source (Bechtel Corporation, USA, 1976). Since the scale of the facilities in the USA is larger, the scaling down to small facilities of 100MW etc. may indicate smaller requirements than actually necessary.

760 tons of concrete but requires 2580 tons of aluminium. Of course, the least raw materials are required for importing oil.

LNG import (transport) requires 44000 tons of steel and 175000 tons of concrete for setting up 1000 mmcf per day capacity. On the other hand, stock pile of same capacity requires only 406 tons of steel and 31 tons of concrete.

In cases of underground coal mines, 420,000 tons of steel and 765,000 tons of concrete are required for installing annual capacity of 100 mt of coal production whereas the surface mines of the same capacity require 473,000 tons of steel and 350,000 tons of concrete.

In addition, most of these facilities use cast iron, aluminium, copper, etc., which are also given in Tables 9A and 9B, and so are the break-up of steel into carbon steel, low alloy steel and stainless steel. Water, land and manpower requirements, which are not considered here, are discussed by M. Grenon and A. Grübler in their papers in WELMM (Water, Energy, Land, Manpower and Materials) conference.

Do raw materials pose additional constraints ? Unfortunately, due to inadequate data, this question cannot be answered in terms of the reclassified country groups. The data is available at the world regional level. It is also unsatisfactory to look at the data at a world-regional level because some countries might have surplus raw materials but no energy industries and some may have energy industries but may import raw materials. It may happen that on a world-regional basis these imports and surpluses may balance out,giving no indication of the difficulties faced by the individual developing countries. The United Nations Yearbook of Industrial Statistics unfortunately does not give detailed country-wise information so as to aggregate this again in terms of South 1, South 2 and South 3 countries. Moreover, most of the raw materials are also used for other industries, building construction and mining. Therefore, it is difficult to draw implications exclusively for the energy industries based on this factor.

In Table 10 one could see that the production by the developing regions as a fraction of world production for these primary resources requiring low level processing, such as cement or pig iron, is in line with their shares of energy consumption in the world total. However, this is not the case with materials requiring high levels of processing, such as steel and aluminium, where the shares of the developing world region in the world total appear rather small. The same holds for other items related to energy development, such as liquid pumps, exca-

Table 10. Basic material production necessary for manufacturing capital goods for energy industries in the developing regions.

Commodity in 10^3 t ISIC No.	Regions	1971	1975	1980
Cement	Africa	14122	16415	22465
369204	S.America	24739	32908	22465
	Asia	56998	77350	108240
	China	17000	46260	79860
	World	161859	712223	867720
Pig Iron	Africa	308	568	517
371007	S. America	1175	1394	1448
	Asia	129	160	230
	China	-	-	-
	World	24285	23286	19352
Crude Steel	Africa	92	140	178
for Castings	S. America	163	170	174
371016	Asia	54	60	72
	China	-	-	-
	World	13170	16998	21379
Copper, Blister	Africa	1107.3	1177.5	1101.9
and Other	S. America	790.5	882.8	1301.7
Unrefined	Asia	57.4	86.2	131.4
372001	China	180	180	200
	World	6466.2	7492.1	8085.5
Aluminium	Africa	161.8	197.5	332.6
Unwrought	S. America	126.1	247.2	834.3
372022	Asia	206.0	370.8	376.0
	China	260	280	360
	World	12104.5	14382.9	18694.7

The total for developing regions is not done because of inadequate coverage.
Africa excludes South Africa.
Asia excludes the USSR, Japan and China.
S. America does not include Mexico.

vating machines, cranes, compressors, where the shares of developing world regions in the world total is very small, as shown in Table 10.

4.3. Capital Goods for New and Renewable Sources of Energy (NRSE)

Since at present, the contribution of NRSE is negligible, there is no data available for manufacturing or trade of capital goods for NRSE. However, it is essential to draw some implications of a policy to pursue NRSE.

Much of the equipment necessary for NRSE is low or medium technology items.

- Bio-gas digesters, if bio-gas is used as fuel, could almost be made in the rural areas, except pipes for transporting gas, good quality burners and the gas holders may have to be obtained from manufacturers located in towns or urban areas. If used in engines, for mechanical purposes, it requires additional hardware, which is not simple.
- Wind mills, if used for mechanical purposes, require low technology items. Blades could be made of cloth, wood or iron and steel. 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 require high technology items. However, solar photovoltaic and solar power plants for electricity generation—even if it is based on collectors— require high technology items.
- Items required for mini hydro power plants are given in Annex 1 and do not include high technology items.

However, there are two conditions which must be fulfilled for sucessful implementation of NRSE:

- Most of the NRSE applications require accurate siting and coordinating. For example, height and location of a wind mill are so crucial that if it is placed 50 metres away from the optimal site, it could mean 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 operate together.

- 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 by computer industries where the march towards bigger and better computers stopped and turned to small but large numbers of computers spreading the computing power to many persons. But new organizations and ways of working are not yet developed.

5. HIGHLIGHTS AND IMPLICATIONS

(a) Imports of capital goods for energy industries vs. oil imports:

In 1979, developing countries spent nearly 18 to 20 billion US dollars to import capital goods for the energy sector, as against 27 billion dollars to import crude oil (In addition, 10 billion dollars were spent for petroleum products, much of which are imported from the developed countries.) Some of the individual countries spend for the energy equipment as much as that for importing crude oil and oil products. Thus, imports of capital goods for energy industries and imports of oil are both competing for foreign exchange for the energy sector, but the former which is essential for national development, has not received as much attention from the media and policy analysts as the import requirements for oil. In fact, it is expected that in the eighties the import bill for capital goods for energy may exceed the import bill of oil.

(b) Predominance of power in total energy sector:

Investment in the energy sector often claims the largest share of public investment, even more than agriculture, industries or transport, of which power industries claims nearly 60% to 90% investmert especially in non-OPEC countries. The importance of power in the total investment is mainly due to its capital intensiveness and the backlog in power development (and also due to the fact that the oil imports bill is considered annual expenditure). All countries produce electricity but not all have fossil fuels of their own. The power sector in the developing countries claims nearly 5% to 10% of total capital formation in the economy, 17% to 20% of planned investment and 65% to 90% of the development aid and lending for the energy sector.

(c) Countries with critical size for manufacturing:

Seven developing countries, which together represent 58% of population, 67% of energy consumption and 64% electricity capacity have the critical size and perhaps also the skills (but not the best organizations) required for manufacturing most of the items except some very high technology items, related to power units larger than 500 MW, nuclear power plants. etc. These countries are grouped together in South 1. Of course, different countries within South 1 have varying abilities. For example, India and China are practically self-reliant except for a few items and even in a position to export, although presently it is at a very low level.

(d) Medium and small size countries:

Nearly thirty developing countries have individually moderate requirements for capital goods. Together they represent 27% population, 24% energy consumption and 29% electricity capacity. Some of them are already partially manufacturing low and medium and occasionally a few high technology items (and perhaps exporting them at small scale). If they wish to be completely self-reliant, they may have to make joint ventures and cooperative agreements with other countries, or through country groups, such as ASEAN, LAFTA, etc. South 3 on the other hand, could produce at most low technology items and will be dependent on imports. It should be mentioned that classification of low, medium and high technology is convenient for discussing the general trends but is difficult and perhaps unnecessary for labelling all items individually.

(e) Availability of basic materials for manufacturing:

Major factors for manufacturing capital goods for the energy sector are: availability of basic materials, infrastructure, and availability of skills and services. Basic materials required for energy industries are cement, pig iron, steel and steel products (pipes, carbon steel, steel alloy, plants, casting, etc.). cement, copper and aluminium. The share of developing regions in the world production of basic materials is very small. While developing countries sometimes have primary raw materials, such as iron ore, copper and bauxite, they often do not have industrially processed raw materials, such as pig iron, steel or alumimium.

(f) Requirements of engineering services:

Engineering services required for energy industries are for three levels of operations:

(i) Exploration, surveys, feasibility reports and planning

(ii) Layout and construction

(iii) Operating and maintenance.

The first is the most difficult for which foreign help is even required by some of the South 1 countries. In addition, South 2 countries often require partial help for construction and South 3 can barely manage to maintain and operate.

(g) Prognosis for country groups:

As and when developing countries industrialize, their ability to manufacture and export will increase particularly for low and medium technology items. Excluding a few items, there is a time lag before even South 1 countries could fully meet their own needs and export high technology items on a large scale. The trends of prices of those items also bear this out. For example, while during 1967-1978 the prices of high technology items have increased five to six-fold, those of medium and low technology items increased only two or three-fold, some of which could be attributed to general inflation but the rest is explained by more competition in low and medium technology items.

(i) North-South and South-South cooperation:

Over the last two decades the North has built up greater capability to manufacture capital goods than it needs to use due to reduced energy consumption. In principle,in an interdependent world, the developing countries need not duplicate these efforts and could use this idle capacity. However, in practice, the prices of capital goods are compelling them to increase their own manufacturing, if they possess the abilities and the critical size to do so. In a similar way they are increasing their search for domestic oil and refineries in spite of over-capacity in world oil production and refining at the present time. Presently, North-South cooperation is most favourable for South 1 due to the somewhat identical nature of demand for capital goods especially in high technology items. South 2 countries have moderate demand individually, but together they import more capital goods than South 1 countries; in 1978, 29 countries of South 2 spent nearly 12 billion dollars compared to 6 billion dollars by seven countries of South 1. South-South cooperation for low and medium technology items will be most useful and is especially essential for South 3 whose nature of demand may not be fulfilled by the North (such as for small mines, small oil wells of a few tons per day capacity or power plants of 100 kW to 5 MW etc.).

(j) New and renewable energy resources:

New and renewable energy sources would require more medium and low technology items(except photovoltaic etc.) which could be more easily produced by countries of even South 2 and South 3. However, each energy facility, such as wind mills, mini hydro or bio-digesters, requires individual attention about planning and setting it up etc., and may require a large number of semi-skilled persons. This problem could be solved in the long run and could be advantageous for solving the unemployment problem.

Note on the Statistics

Unless otherwise mentioned, data are either directly reported or aggregated and estimated by the author from the following UN sources:

- Energy consumption and production data from Yearbook of World Energy Statistics (1980)
- Trade data from Yearbook of International Trade Statistics (1980)
- Manufacturing data from Yearbook of Industrial Statistics (1980).

Much of the data is collected from the UN statistics classification, reporting which has undergone changes recently. For example, the energy data for country groups, such as developing, developed and centrally planned economies are no longer reported and have to be assembled from country data and may have minor inaccuracies due to omission of small countries.

The trade data in 1980 is also reported in different commodity aggregation than in 1979. For example, commodity with 4 digit SITC classification with regional aggregation reported in Table 4 of this paper is no longer reported as it was in 1979 (for the year 1978).

The Trade Statistics Yearbook (1980), Vol.1, where there is country-wise data, follows more SITC classification code of revision 2 than Vol.2 which reports trade by commodity for the same commodity according to revision 2 and has sometimes different commodity number, e.g. electric power machinery is 722 in Vol. 1 and 772 in Vol.2.

SITC No.	Description
711	Power generating equipment (High technology): Non-electric steam generating boilers including related items such as superheaters, condensers, etc. Steam and gas turbines, steam engines and nuclear reactors are also included. Although steam boilers could be used in other industries as well, their percentage is expected to be small (10% in case of India).
722	Electric power machinery (Medium technology): Converters, generators, motors, rectifiers, transformers, relays, switches.
723	Electricity distributing machinery (Low technology) insulated wires and cables, insulators, insulating fittings, connection scrips, etc.
729	Electrical machinery NES (not elsewhere specified): Batteries, accumulators, lamps, supply motors, measuring and controlling equipment, etc.

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ANNEX A

EQUIPMENT REQUIREMENTS FOR THERMAL, HYDRO AND MINI HYDRO PLANTS

A.1. Detailed breakdown of operations, equipment and costs for constructing thermal power plants

Item	Brief description
I. Site	
1. Cost of land	Includes purchase price of all land necessary for plant operation, privilege acquisition, relocating telephone and power lines, etc. Indicate approximate surface; indicate separately whether land for employee housing is included.
II. Site preparation and engineering	
(Indicate suitably, if the site conditions call for specially heavy and expensive foundations)	
1. Site preparation and improvements	Grading, surfacing, roads, railways, sewers, parking areas, fencing, etc. Indicate separately access roads and railways to the plant area.
2. Underground ducting	For steam, electric cables, cooling water, ash disposal, etc.
3. Cooling-water supply	Engineering work for construction of water intake, water piping, filter buildings, cooling towers, cooling water discharge, etc. but excluding any equipment.
4. Fuel supply and ash disposal	Engineering work on the preparation of ports, railways stations, coal yards, oil tanks, coal bunkers, ash-dumps; and on the construction of buildings housing carriers - but excluding equipment.
5. Heating	Buildings housing boilers, bunkers and hoppers, ash-disposal systems, etc.
6. Chimneys	Structure of chimneys, smoke-disposal system foundations for dust extractors.

Item	Brief description
7.Generators and water system	Buildings housing turbo-generators, condensers and heat exchangers, also the pumps, reservoirs, and water purifying and evaporation plant which make up the water system.
8.Power station and auxiliary buildings	Buildings housing switching-stations, transformers, electric control-post, etc.
9.Other buildings	Administrative buildings, offices, laboratories, workshops and store-houses.
10.Building services	Plumbing, heating, lighting, air-conditioning, lifts and hoists, fire-protection, etc.
11.Others	Local communication, signal and call-systems, drinking-water supply, etc.
III. Handling of fuel and ash: cooling-water supply	
1.Supply of fuel and ash disposal	Equipment of ports, stations and coal-bunkers, travelling cranes, conveyors, weight-bridges, equipment of fuel-oil tanks, piping for fuel-oil, etc.
2.Supplying of cooling water	Equipment of water-intake, valves and filter-cleaning plant; equipment of cooling-towers, ventilators, etc. (give a brief description of the circulating water system).
IV. Boiler equipment	
1.Handling, stocking and preparation of fuel	Equipment of bunkers inside the boiler-house, conveyors, hoppers, scales, crushers, hoppers for pulverised coal.
2.Boilers	Complete boilers, including superheaters and re-superheaters, economisers and air heaters, intake valves, stop valves, screens, burners, forced-draught ventilators, induced-draught ventilators, piping, etc.
3.Ash-handling dust extractors	Equipment for handling ash inside the boiler-house, conveyors, dust extractors, electro-static filters, etc.
4.Piping	Steam and air piping, water distribution and ash-disposal system inside the boiler-house and not forming part of the boilers themselves, valves, steam traps, etc.

Item	Brief description
5. Instruments for the heating system	Instruments for boilers, automatic adjusting equipment, recording devices, etc.
V. Turbo-generators and condension equipment	
1. Turbone-generators and auxiliaries	Turbone-generators and accessories such as stop valves, regulators, generator coolers, exciters, etc.
2. Condensers and cooling water system	Condensers, extraction pumps, air ejectors, cooling water circulation pumps, piping for cooling water.
3. Feed water plant	Feed pumps, heat exchangers, feed water piping, piping for bled steam, reservoirs, reheaters, de-aerators, etc.
4. Make-up water plant	Water purification equipment, evaporation sets, chemical preparation equipment, filters, piping, etc.
5. Instruments	Control instruments of generating sets of water-system, recorders, meters, etc.
VI. Station control rooms	Main transformers, isolating switches, circuit-breakers, busbar sets, instrument transformers, etc. Turbo-generators, auxiliary transformers, sub-stations, switching stations for the plant's own consumption. Panels, switchboards, instruments, switch-gear for remote control, protective equipment, meters, recorders, auxiliary accumulators, etc. Electric cables for connecting generators with the electric station, cables for auxiliary electrical equipment, control and signal wiring, etc.
VII. Miscellaneous	
1. Miscellaneous equipment	Cranes, handling equipment, equipment of laboratories and workshops, other tools, test and research instruments, lubricating and cleaning equipment, etc.

Item	Brief description
VIII. General expenses	
1. Engineering, design and inspection	Preliminary investigations, engineers' fees, consultations.
2. Indirect construction costs	General administration, field supervision, purchasing, personnel, insurance, security, various temporary structures, temporary roads and railways, fences, offices, workshops, utility services, electric power, compressed air, steam, construction equipment and tools, medical service, etc.
3. Commissioning	All starting up costs.
4. Fees, etc.	Legal fees and royalties of patents, insurance, etc.
5. Interest during construction	

Summary of constructions costs:

I. Site.

II. Site preparation and engineering.

III. Handling of fuel and ash; cooling-water supply.

IV. Equipment of the heating system.

V. Generators and water system.

VI. Electric stations and control rooms.

VII. Miscellaneous.

VIII. General expenses.

Source: Economic Commission for Asia and the Far East, Bangkok, Thailand. "Thermal Power Stations - A Techno-Economic Study". United Nations, New York, 1970.

A.2. Equipment for tunnel for hydro-power projects

The tunnel construction equipment can be divided into four groups:

(a) Excavation equipment - Drills, Jumbos, and Mucking machines.

(b) Tunnel haulage equipment - Locos, and Mine Cars, etc.

(c) Concreting equipment - Concrete Pumps, Placers, and Shutters, etc.

(d) Facilities necessary to serve the above three groups - such as ventilation equipment, compressed air equipment, dewatering equipment, etc.

In addition, the hydro-power generation may require turbines, generators and other equipment similar to those required in thermal power plants.

Some of the equipment mentioned here is of similar nature to that required for underground coal mines.

Source: D.R. Singha and Narendra Singh, "Planning of Construction Equipment for a Long Tunnel - A Case Study". In: Proceedings Volume 1 of the Seminar on Accelerated Hydroelectric Development in India. National Hydroelectric Power Corporation Limited and Central Board of Irrigation and Power, New Dehli, March 1981.

A.3. Setting up of Workshop Complex for Hydro-Power Plants

The following shops of adequate capacity and with adequate amount of equipment are necessary for a big sized hydro-electric project:

(a) Structural shop for fabrication of structural jobs on the project.

(b) Machine and foundry shop.

(c) Penstock fabrication, testing and painting unit.

(d) Tractor-cum-Excavator-cum Heavy Earthmoving repair shop.

(e) Carrier repair shop.

(f) Light vehicle repair or Auto shop.

(g) Lubrication shop.

(h) Pipe and pumping repair shop.

(i) Rigger's loft.

(j) Electric repair shop.

(k) Drilling and grouting equipment repair shop.

(l) Pneumatic equipment repair or Bit shop.

(m) Carpentry shop.

(n) Reinforcement Bending shop.

(o) Sheet metal shop.

(p) Painting shop.

(q) A Research Laboratory for exercising quality control.

(r) Adequate Stores complex, Steel yards, etc.

If however, the contractual form of construction is adopted, the functions of the above shops through contractors agencies in adequate capacity must be established so that pace of construction is not obstructed due to inadequate facilities on acccount of these. At many projects, the non-provision of these facilities has caused a lot of strain and delays.

Source: S.N. Agnihotri and M.L. Sekhri. "Construction Planning, Equipment and Induction of Modern Technology on Hydro-Electric Project". IN: Proceedings Volume 1 of the Seminar on Accelerated Hydroelectric Development in India. National Hydroelectric Power Corporation Limited and Central Board of Irrigation and Power, New Dehli, March 1981.

A.4. Identification of Production of Materials and Equipment Used for Mini-Hydro Generators

A. Materials for civil engineering work

- Granular materials; clay and silt.
- Cement.
- Steel construction bars/
- Pressure pipes fpr penstocks(steel, PVC, polyethylene, asbestos-cement).
- Gate and butterfly valves.
- Grates and gates.
- Wood.
- Steel cables.
- Bricks.
- Tiles.
- Nails.
- Explosives.
- Galvanized wire mesh.
- Bolts, nuts, washers and screws of various types.

B. Production of equipment and tools for civil engineering works

- Pick-axes.
- Spades.
- Wheelbarrows.
- Motor pumps.
- Concrete mixers.

C. Production of electro-mechanical materials

- Copper and alloys.
- Structual steel.
- Stainless steel.
- Shafts.
- Bearings.
- Electrical conductors.
- Post and accessories.
- Electrical materials.

D. Production of electro-mechanical equipment

- Hydraulic turbines.
- Speed regulators.
- Electricity generators.
- Measuring instruments(voltmeters, ammeters, power factor meters, frequency meters, kilowatt meters and energy meters, manometers).
- Mechanical transmission systems (gears, belts and couplings).
- Measurement and high-tension power transformers.

E Industries

- Casting
- Metalworking and engineering
- Precision engineering
- Electrical engineering and allied industries

Source: The UNIDO Technology Programme and The Latin American Energy Organization (OLADE). "Mini Hydro Power Stations(A Manual for Decision Makers)". UNIDO/IS.225, 27 April 1981.

ANNEX B

COUNTRY-WISE ENERGY RELATED STATISTICS FOR SOUTH 1 AND SOUTH 2

Table B1. Energy and Electricity Consumption, Growth Rate. and Population

SOUTH 1

Country	Commercial Energy Consumption 10^3 toe Total 1970	1981	Growth Rate	Energy per cap. 1981 kgoe	Total Electr, Capacity 1000 kW	Population in millions
Argentina	26050	33185	2.2	1182	12220	28.2
Brazil	28652	63275	7.5	521	37832	120.5
China	204796	393270	6.1	397	71000	991.3
India	52511	93691	5.4	137	35384	690.2
Mexico	36540	86460	8.1	1161	19895	71.2
Venezuela	16905	31006	5.7	2168	9224	15.4
Korea Rep.	14361	37716	9.1	974	10736	38.9
TOTAL	379815	738703	6.2	378	197291	1995.7

Table B2. Energy and Electricity Consumption, Growth Rate and Population

SOUTH 2

Country	Commercial Energy Consumption 10^3 toe Total 1970	1981	Growth Rate	Energy per cap. 1981 kgoe	Total Electr. Capacity 1000 kW	Population in millions
Algeria	3132	19259	17.9	983	2006	19.6
Angola	612	705	1.3	97	600	7.8
Ghana	986	967	10.0	80	900	11.8
Ivory Coast	762	887	1.4	107	1028	8.5
Kenya	802	1518	6.0	89	541	17.4
Morocco	1967	4820	8.5	233	1179	20.9
Mozambique	764	672	9.0	62	1800	12.5
Nigeria	1888	12060	8.3	151	2497	87.6
Tunisia	1015	2965	0.2	455	900	6.5
Zaire	1010	1376	3.0	51	1716	29.8
Egypt	5965	15418	9.0	355	4500	43.3
Iraq	3917	5531	3.2	409	1200	13.5
Syria	1663	5358	11.2	575	1112	9.3
Guatemala	705	1151	4.5	154	575	7.5
Chile	7421	7187	0.5	638	3210	11.3
Columbia	8279	14387	5.1	518	5370	26.4
Ecuador	1155	3744	11.2	433	1100	8.6
Peru	5514	7477	2.8	409	3300	17.0
Bangladesh	0	2854	-	32	981	90.7
Indonesia	9524	25017	9.1	166	2860	149.5
Iran	18674	23638	2.2	601	5300	40.1
Korea Dem. Rep.	19582	33582	5.0	1833	6500	18.7
Malaysia	4098	9783	8.2	679	2328	14.2
Pakistan	7318	12837	5.2	152	4098	84.5
Philippines	6898	12036	5.2	243	4775	49.6
Thailand	4588	11035	8.3	229	3760	48.0
Hong Kong	2592	5273	6.6	1023	3365	5.5
Saudi Arabia	1841	10765	17.4	1155	3100	9.3
Turkey	11564	22384	6.1	483	5134	45.5
TOTAL	134236	275706	6.8	301	75630	914.9

Table B3. IMPORTS OF SOME OF THE ENERGY RELATED CAPITAL GOODS AND ITS COMPARISON WITH OIL IMPORTS IN 10^6 US DOLLARS 1980

SOUTH 1

Countries	Non-electric Power Machinery	Electric Power Machinery	Electric Distribution Machinery	Electric Machinery	Total	Oil Related Imports
	SITC No.711	722	723	729		
Mexico	472.1	190.0	274.4	166.2	1103.5	291.7
Argentina	105.6	117.2	-	106.7	329.5	476.7
Brazil	254.6	475.3	-	537.2	1267.1	7314.1
Venezuela	226.9	331.1	-	203.5	761.5	109.7
China	data not available					
India	109.8	72.3	-	94.3	276.4	1640.3
Korea, Rep.	42.1	-	33.9	-	76	6659.5
TOTAL	1211.1	1186.7	308.3	1107.9	3814	16492
% of each item in total	31.7%	31.5%	8.1%	29%		

Precise data for China is missing. However, it is known that China has been making most of the equipment for almost a decade.

Source: Yearbook of International Trade Statistics (1980), UN, New York.

TABLE B3 continued

Countries	Non-electric Power Machinery SITC No.711	Electric Power Machinery 722
Algeria	28	12.4
Angola	8.3	10.2
Ghana	10.8	7.8
Ivory Coast	5.1	12.8
Kenya	30.2	20.9
Morocco	20.1	21.3
Mozambique	13.3	14.8
Nigeria	186.2	545.9
Tunisia	61.4	71.9
Zaire	11.3	14.4
Egypt	37.1	76.8
Iraq	134.8	145.9
Syria	1.3	21.2
Guatemala	20.8	11.3
Chile	20.4	37.1
Colombia	50.4	52.2
Ecuador	40.3	6.6
Peru	53.9	21.8
Bangladesh	16.5	18.8
Indonesia	390.7	291.9
Iran	649.6	526.6
Malaysia	128.5	152.4
Pakistan	50.8	71.9
Philippines	126.6	126.3
Thailand	170.5	171
TOTAL	2216.1	2464
% of each item	29.8%	33.2%

SOUTH 2

Electricity Distribution Machinery	Electric Machinery	Total	Oil Related Imports
723	729		
117	-	157.4	169.9
1.6	8.9	29	28
3.4	10.9	32.9	179.4
26.3	-	44.2	273.5
3.5	2.3	56.9	307.4
72.5	-	113.9	70.8
2.8	2.8	33.7	27.4
156.4	354.4	1242.9	245.8
21.7	46	201	504.6
8.4	29.8	63.9	91.2
32.9	48.5	195.3	3.1
45.2	56.9	382.8	-
43.6	-	66.1	822.7
2.7	14.8	49.6	145.9
5.3	34.5	97.3	382.2
-	40.4	143	137.6
53.8	27.4	100.7	13.6
-	24.5	100.2	336
11	10	46.3	193.9
108.8	161	952.4	1753.7
147.4	326.3	1649.9	-
31.6	440.4	752.9	632.3
23	52.5	198.2	1442.1
22	98	372.9	1466.5
19.2	-	360.7	1130.1
960.1	1790.3	7430.5	10385
13.5%	24.1%		

ANNEX C

ELECTRICAL EQUIPMENT MANUFACTURING CAPACITY IN INDIA*

During the last two decades, India increased its capacity to manufacture domestically to meet most of her needs. As Table C shows, during the third five year plan in 1961-66 it had negligible capacity and used units of 60MW. By 1980 96% of her requirements for 220MW were manufactured within India and is expected to develop capacity to build 500MW power plants in future. India already exports switch gears, transmission towers, boilers and other items to other developing countries and offers consultation services.

Table C. Increase in India's self-reliance.

Years	Five Year Plan 1	Share of Indigenous Equipment in Total	Capability in Unit Size
1961-66	Third Plan	negligible	60MW
1969-74	Fourth Plan	25%	110/120MW
1974-79	Fifth Plan	85%	220MW
1980-84			220MW
	Sixth Plan	96% + exports of some items	+ partial ability 500MW

* Abridged and compiled from the Report of the Working Group on Electrical Power Equipment (1979), Department of Heavy Industry, New Dehli.