CAPITAL GOODS FOR ENERGY DEVELOPMENT: POWER EQUIPMENT FOR DEVELOPING COUNTRIES

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1. INTRODUCTION

1.1. Background

Energy problems of the developing countries have three facets: large import bills for oil and oil products, scarcity of biomass for cooking and import bills and investment required for energy development. While the first two are discussed often in the literature, the third, although of great concern to the national governments and many aid agencies, needs to be analyzed in more detail. The magnitude of the third problem can be assessed from the fact that in 1980 as estimated by the World Bank (1), roughly US-$ 34 billion were invested for the energy sector, of which US-$ 25 billion were used to import machinery or capital goods for energy development. The term "energy capital goods" (e.c.g.) in this paper implies equipment necessary to set up new energy facilities[1] 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 two figures can be compared with US-$35 billion for importing crude oil and US-$10 billion for oil products for the same year. It is interesting to contrast them because both of them not only compete for foreign exchange but are partial substitutes of each other. That is, with more energy capital goods it may be possible to partially reduce the oil imports. In 1980, the South claimed 12% of the total world imports of crude oil, but it had 30% to 60% (depending upon the equipment) of the share of the world imports for the capital goods for energy (2).

[1]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. "Power" essentially means electric power because that is the largest component. A small component of motive power may also be included here but most of it is used in the transport and industries sector and not for energy facilities. Electric power is the rate at which electricity (a form of energy) is supplied. However, since capital goods required for "electricity" or "power" are the same, both the terms are used without making a distinction.

In 1983, however, there is a drop in the above figures, namely imports of US-$15 billion for capital goods (for electric power) and the overall share of inputs in the world market dropped from 33% in 1980 to 27%. This may be partially attributed to high exchange rate for the US-$, low economic growth in the developing countries and reduction in foreign aid. 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 and for *building up* the economy.[2]

Electricity is a basic infrastructure necessary to enhance the process of industrialization. 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 (Jankowski (3)). This is even more true after 1973, when due to the rise in oil prices, the share of oil in total energy began to fall. The reasons for this are not difficult to find. On the supply side, electricity is a versatile form of energy that could be generated from several indigenous sources, e.g. hydro, coal, gas, nuclear, geothermal, etc. On the demand side, it is a highly efficient and versatile form of energy source that could be used in thermal and electrochemical 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. Since all countries require electricity, the question of import and/or manufacturing of equipment related to electricity concerns all developing countries.

The procurement of electric power equipment by developing countries does

[2]Even so, the comparison is valid because what we are comparing here is streams of annual commitments of foreign exchange and *not* investment per unit energy.

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 percent in 1983. Their share in the world trade rose from 27 percent in 1970 to nearly 34 percent in 1980. (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 eighties, major share of the business is expected from the developing countries.)

In order to reduce the payments in foreign exchange and simply to increase one's self-reliance, the developing countries need to step up their efforts for domestic manufacturing of electric power quipment 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 industrialization. However, the priority for manufacturing electric equipment would depend on the extent of electricity required, patterns of industrialization, priorities of other sectors which may claim skilled personnel, financial resources, etc., in addition to the costs of inputs and prices of outputs nationally and internationally.

The aim of the present paper is to identify these conditions for different groups of developing countries, for different levels of technological complexities and by different modes of procurement, whether through imports or manufacturing.

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 deals with the questions related to energy supply rather than demand, a short discussion on the structural changes that took place recently in the demand patterns is essential so as to have estimates of the required capital goods. In particular, recent changes in the production and consumption growth rates of energy as a whole and its two important elements, oil and electricity, and changes in the energy mix are the most relevant indicators.

2.1.1. Structural changes in energy consumption patterns and their implications

Two major changes that took place after each rise of oil prices, i.e. in 1973 and in 1979. They are:

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 taken place is the reduction in the growth rates over their previous prevalent values. While in the fifties and sixties, growth rates increased compared to previous decades, in the seventies, especially after 1973, the growth rates have decreased. Some of the recent statistics regarding this are summarized in Table 1. 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.

It can be seen in Table 1 that total energy consumption growth rates for the world energy demand which was 4.61% during 1965-73, came down to -0.93% during the period 1979-81 as indicated in (4). The growth rate for the developing countries during the period 1979-1981 was 3.0% as compared to 7.8% in 1965-73. The growth rates for oil consumption relative to the growth rates of total commercial

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

Country Groups	Time Period	Production: Comm. Energy	Production: Oil	Consumption: Comm. Energy	Consumption: Oil	Consumption: 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	4.88	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 are 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. However, general pattern indicated here is not likely to alter drastically by these minor changes.

energy consumption for all the groups of economies became lower for the post-1973 periods. For the developing market economies, oil consumption growth rates 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.

Interestingly, even though the share of electricity in total primary energy is 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 (5) planned to spend 14.5% of their development expenditures on energy, of which 69% was for electricity. In Kenya (6), 10.5% of its capital formation in 1983 was in the energy sector, most of which was in the power sector. In India, according to the sixth five-year plan 1980-85 (7), 27% of the sixth plan expenditure was for the energy sector, and of that 70% for the power sector. The desirability of such predominance of the power sector in the energy plans has been questioned recently (World Bank, 8) and the 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 plans of the developing countries is due to many reasons and will claim a major share of investment in the energy sector.

The annual growth rates of the electricity consumption has decreased from 10% in Africa and Far East and 14% in Latin America in the sixties to 8% and 10% in the seventies, respectively (Parikh J., 9). In spite of the high oil prices, high growth of electricity (of about 6%) is expected to continue in the eighties because of the backlog and very low levels of per capita electricity consumption in spite of the recent investment and growth rates.

Table 2 shows that, in 1980 (Parikh J., 10), the shares of the developing countries in the world market were 35% for steam turbines, 47% for gas turbines, 52% for electricity distribution equipment, etc. Thus, the imports of only a few items add up to US-$15 billion.

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

2.2. Trends in the World Trade of Electric Power Equipment

Let us look at the basic facts, recent trends and current positions regarding the trade of the electric power equipment and their destinations during the period 1970 to 1983 by country groups. In fact, since the trade data is more reliable than manufacturing, much of the inferences could also be drawn with regard to manufac-

Table 2. Changes in imports of capital goods (1980)

Item description	SITC No.	Imports in 10^6 $ 1980**	Year	Shares of importers Dvlg.-countries†	Africa	Latin America	Asia
Steam turbines*	712		1971	22.7	1.1	8.5	13.0
		1110	1979	35.5	2.1	8.9	24.5
Other power generating machinery*	718		1971	23.2	5.5	11.6	6.1
		1726	1980	29.1	-	-	17.5
Electric power machinery NES	771	3432	1980*	27.1	2.3	0.4	23.7
Switch gears Parts NES	772		1971	22.1	4.6	8.1	9.1
		12589	1980	34.3	5.9	7.3	20.8
Electricity distrib. equipment	773		1971	37.8	8.6	7.2	21.0
		5462	1980	51.7	8.9	8.4	34.4
Transistors, valves, etc.	776		1971	10.6	0.5	4.9	5.2
		15162	1980	24.8	0.3	2.6	21.9
Electric machinery	778		1971	25.6	4.3	8.3	12.8
		14403	1979	26.2	5.2	6.0	15.0

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. The revision involves different no. of SITC commodity.

† This total may exceed the sum of the three regions because of small countries in Oceania and centrally planned Asia, which are excluded. Sometimes the percentage distribution for 1980 is not available and the 1979 distribution is reported. No data prior to 1976 available for the item 771.

turing the power equipment from trade data, albeit indirectly, as will be shown later. Discussions are split into three categories:

(a) Some general global trends will be discussed at three digit levels[5] and then

[5] 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 no.711, 722 and 723. This is not the only equipment required for electricity generation, respectively. Therefore, the final figure of total trade would be much larger. In the introduction, an average increase of 30 percent is assumed due to remaining equipment.

(b) structural changes in the trends;

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

2.2.1. General trends[6)]

They are illustrated in a short summary shown in Table 3. It can be seen that in current dollars, the total world exports amounted in 1970, 1980 and 1983 to US-$ 13, 39 and 34 billion, respectively. However, the shares differ for different items; for the electricity distributing machinery it is nearly 45 percent, whereas for non-electric power generating machinery it is 26 percent, i.e. high technology items, such as boilers, turbines, etc. This is because there are some developed countries which also import these high technology items.

Table 3. Summary of the world trade in the electric power equipment industry (in billion US-$ and constant 1975 prices)

	Non-electric power generating machinery SITC Division: 711				Electric power machinery and switchgear 722				Distribution equipment 723				Total			
	1970	75	80	83	1970	75	80	83	1970	75	80	83	1970	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 Statistics (1975, 1980)

2.2.2. Structural changes

There are several structural changes which are highlighted below.

There was a substantial rise in the world trade of power equipment of all types from US-$ 13.2 billion to US-$ 39.3 billion during the period 1970-1980, after which

6) This discussion includes only items under SITC nos.711, 722 and 723 and excludes miscellaneous items which could add to 30 percent of the costs.

it dropped in 1983 to US-$ 33.9 billion. This is due to the reduced electricity demand, which has become a worldwide phenomena and is especially the case for the developed countries. However, the reasons are different for both groups. While in the developed countries it is in part due to increased efficiency of electricity, in the developing countries it is mainly due to their inability to finance such imports.

The shares of developing countries in the world market went up from 27 to 37 percent from 1970 to 1980 but they declined to 32 percent 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 countries.

For all the three items, the share of the USA in the world exports during 1970 to 1983 remained the same with some minor fluctuations, but the shares of Japan increased all along from 1970 to 1983. As a result, 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 high during 1983 compared to 1980 and these countries would be expected to be more competitive than the USA.

The largest exporters of capital goods for energy are the EC and the USA but Japan is also claiming a share in recent times. Table 4 shows the exports of the major items. The general breakup of all items appears to be 50:17:13 respectively for the three exporters. The information in this table should be interpreted with care and the annex on the difficulties with data needs to be kept in mind. EC also imports some items in the same general commodity number and some of these exports could be to countries within the EC. However, even when that is taken into consideration, its *net* exports are often the largest and, if not, at least significantly high.

Table 4. Changes in exports of capital goods

Item description	SITC No.	Exports in 10^6\$ 1976	1980	Annual Growth rate(%) 76-80	Year	Shares of Exporters EC	Japan	USA
Steam boilers & aux. plant	711	989	1594	12.7	1971	56.3	10.7	19.3
					1980	47.5	22.2	19.6
Steam turbines	712	793	1439	16.1	1971	52.7	10.8	13.1
					1980	49.5	14.2	19.2
Other power generating machinery	718	550	1903	36.3	1971	48.4	20.5	17.4
					1980	50.8	5.1	24.8
Electric power machinery NES	771	512	3304	59.3	1980	50.2	17.7	9.6
Switch gears Parts NES	772	5661	12603	23.7	1971	59.7	7.1	17.2
					1980	55.1	12.9	14.1
Electricity distrib. equipment	773	2641	5279	18.9	1971	53.7	13.3	10.3
					1980	48.2	17.7	10.1
Transistors, valves, etc.	776	5863	13465	23.1	1971	46.5	7.6	33.7
					1980	27.7	16.1	18.1
Electric machinery	778	7133	14190	18.8	1971	54.1	12.0	17.1
					1980	51.0	16.0	16.4

See footnotes for Table 2. The exports are not all to developing countries for which Table 2 for imports needs to be seen. Some of the items are used for general industrial purposes and not for power generation alone.

There was a dramatic rise in the world exports in value terms around the years 1976-1978 (sometimes as much as two- or four-fold) for some high technology items. Since it is unlikely that so much additional capacity was created in less than two years, it is most plausible that significant rise in prices took place. For example, exports of switchgears jumped from \$1045 million in 1976 to \$4803 million in 1977 and exports of pumps for gases increased from \$534 million to \$2294 million during 1977-78.

2.3. Integrated Planning for Electric Power Equipment: National Objectives and Economic Planning

It is essential that integrated planning should be done so as to be in harmony with the national objectives, economic planning and development of other sectors of the economy including the various subsectors.

To set the national objectives, the availability of natural resources, whether land, mineral resources, water, soil, etc., geo-climatological aspects as well as cultural and traditional aspects need to be considered so as to maximize the natural advantages and to minimize its vulnerabilities and risks. These national objectives and rationale behind them would have to be considered for economic planning. For example, low income countries, whose primary goals would be to ensure basic necessities to people, may emphasize food production: therefore, substantial shares of energy and electricity would be required for food processing, households, irrigation, etc. (Exceptions to this are India and China, where due to their large sizes, a significant industrial base is necessary.) On the other hand, high income developing countries which are also industrializing may need different types of industries, rather advanced service sector and therefore, their energy and electricity requirements would be different. Thus, economic planning (Parikh J., 11) would lay down the ground rules for the interrelationships for the development of several sectors, e.g. agriculture, industry, energy, other sectors, such as transport, housing, etc. What concerns the present paper is the planning of industry and energy and the linkages between industry-energy-electricity.

Figure 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.

Long-term energy planning is a prerequisite prior to identifying actual projects for energy development as well as planning for manufacturing power

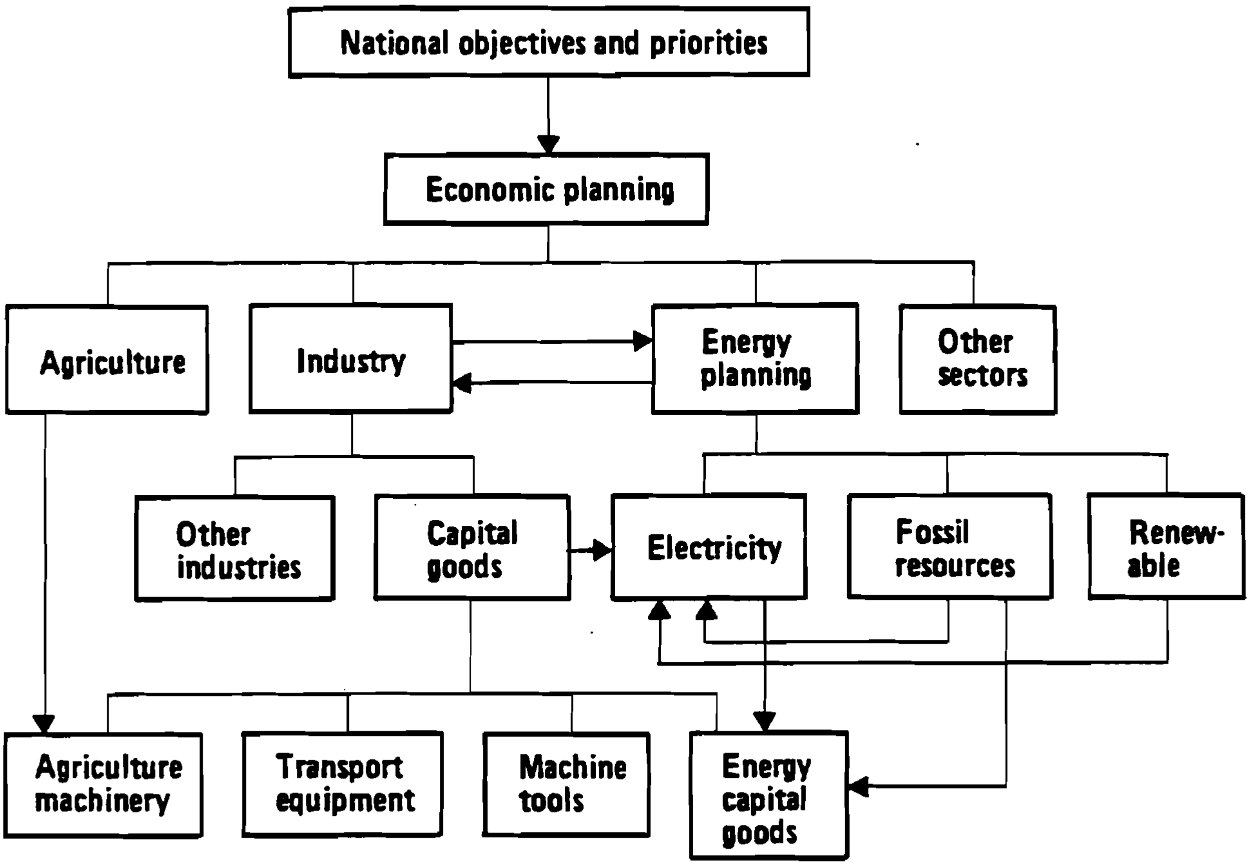

Figure 1. Interdependence of sectors indicating the need for integrated planning

equipment. Energy planners should consider the future demand for energy for the rising population and income, availability of mineral and renewable energy resources, the need for fuel-substitution through electricity, if any, and in general the role of electricity in the overall energy requirements in view of the abundance or shortages of other energy resources. Moreover, electricity generation itself would require either mineral or renewable energy resources. This plays an important role in the electricity planning.

Long-term industry planning also would require consideration of available skills, mineral resources, supply of intermediate goods, technical infrastructure and available financial resources. In general, industries based on primary resources, such as textiles, paper, cement, etc., have received greater attention in the developing countries than capital goods industries which require higher infrastructure, skills, capital and assured demand for them of high magnitudes. Even among the capital goods sector, there are a variety of alternatives and priorities would have to be assigned among them, e.g. agricultural machinery, machine tools, transport equipment, energy-related capital goods, etc.

Should the developing countries continue to import or should they try to manufacture some equipments, which countries should or should not manufacture and what equipment? We discuss this next as well as alternative paths to self-reliance.

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.

In this section, principles of classification of technologies for different commodities and grouping of the countries are developed.

3.1. Classification of Equipment into Levels of Technologies

As indicated in (10, 12), the list of equipment is so large that some principle of aggregation is required. This aggregation is more for convenience and clarity of issues and not for making actual plans and need not be 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 transmisson 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 some even small size items may require precision of high order 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 labor intensities or current prices which are subject to major revisions and which affect mainly the economic evaluation. It seems therefore reasonable to talk first about the feasibility of manufacturing capital goods for energy development. This basis is especially suited for capital goods industries for 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 gives only a general demarkation and would undoubtedly have exceptions depending on particular situations. The classification is expected to show broad patterns.

3.1.1. High technology items

These are often large size equipment and/or which require high skills and precision in manufacturing. Sometimes they are not required in large number and therefore there are only a few manufacturers; often only one in a country, if any (Surrey J., 13). They include large items like turbines, generators, boilers, or precision items such as controlling equipment, etc., all of which require high order of skills and precision to manufacture. They relate in particular to large scale power generation and distribution, off-shore oil exploration, deep coal mines, etc. Occasionally they are required 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 required in 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 required by industries other than the energy industries leading to moderate size demand.

3.1.3. Low technology items

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

It should be stressed again that some items such as insulating cables or transformers may require 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+China

It is conventional to classify developing countries according to geographical locations (Africa, Mid-East, etc.) or income levels (high, medium, low income countries of the World Bank) or oil importers, oil exporters, OPEC, non-OPEC, etc. None of the above classifications are appropriate for explaining manufacturing capabilities in general but e.c.g. in particular and requires a classification which considers *critical size* of the economy required for developing domestic manufacturing capabilities. The countries with significant domestic manufacturing base have large demand due to either large population or high income. Thus, classification based on per capita indicators would be inadequate.

The following classification of countries is suggested which seems to be appropriate for discussing structural changes in North-South trade. 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.

South 1 (or big countries): This group consists of those countries presently engaged in manufacturing equipment requiring skills and equipment of somewhat large-scale nature. Thus, it includes countries with large industrial base, such as South Korea, and on the other hand large countries, such as China (which is also included here because the characteristics are similar to the countries of South 1, although it is in the northern hemisphere), 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 for the power capacity are of the order of 1000MW. Part of their demand, either due to large size (India) or due to high income (Venezuela) or both (Mexico) is for large scale equipment, such as boilers and turbines for 200 MW to 800 MW plants, 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 these equipments. But such exports are at a very small scale because some of them, at present, could barely keep up with their own demand targets. Note that India and China, which are low income countries are included along with Brazil and Mexico and other high-income countries, simply because they have 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 or Malaysia, which has also 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 equipment for power.

Nature of trade with South 1: Thus, the export from North to South 1 would be of restricted nature involving mainly some high technology items but nevertheless the most favorable because of the large demand and of scale which is compatible with the one in the North; for example, large size units larger than 500 MW typically used in the developed countries. The names of the countries are given in Annex 2 along with their attributes relating to energy sector. Though limited to high technology items, the exports are still attractive because of the compatible scale and large orders.

South 2 (or medium countries): 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. This group includes medium-sized countries ranging from Colombia, Peru, Pakistan, Indonesia, Malaysia, etc. Their population, 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. They do not manufacture high technology items. They would generally import partial needs of capital goods from the North but their requirements are small individually but at a reasonably large scale collectively. They could import some of the capital goods from South 1 groups of countries also, as and when South 1 would have excess capacity beyond their own requirements.

Nature of trade with South 2: They import items of high and medium level but require medium or small scale items (50MW to 200MW plants) and therefore could amont to special order requiring reorientation for the North. Their demand is, however, collectively larger than by South 1 countries.

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, which may find it even difficult to *maintain* the power systems due to lack of spare parts and skilled personnel. They may require assistance from the North and South of not only the financial nature but also technical assistance for power system planning. Their annual increase in demand is of 1MW to at the most 50 MW and sometimes even of kilowatt range which is much less than the standard unit size of 500 MW 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. It is possible that they do not make "interesting clients" for the North strictly for trade reasons. However, they suffer the most from fluctuations and uncertainties in energy supply and efforts need to be made to help them.

Note that the classification had to be based on *absolute* rather than per capita level of power capacity or energy consumption to address the issues which are raised in this paper. Secondly, there will be always border-line countries which could be in the neighboring group depending upon the cut-off point chosen for the production and to that extent border-line countries grouping would be subjective. Exceptions had to be made in 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 the 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 way of organizing countries leads to clearer patterns and explains variations among them for three indicators:

- Energy consumption and capacity for electricity production
- Imports of capital goods
- Manufacturing capital goods.

South 1, South 2 and South 3 represent 7, 29 and 92 countries and have 59%, 27% and 14% of population of developing countries, respectively.

3.3.1. Energy consumption and capacity for electricity generation

Table 5 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% and 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 2. 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 much larger share. On the other hand, the countries of South 2 make 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. It is emphasized that only four major commodities for power are considered and that they represent only a part of the total imports of capital goods for power

Table 5. Population, energy consumption, its growth rate and power capacity in reorganized developing regions

Country Groups	Number of countries[a]	Commercial Energy Consumption (10^6 toe) 1970	1981	Growth Rate (%) 1970-81	Electricity Capacity (GW)[a] 1981	Population 10^6 mid-81
South 1 (Big)	7	380 (67%)	739 (67%)	6.2	197 (64%)	1955.7 (58.4%)
South 2 (Medium)	29	134 (24%)	276 (25%)	6.7	76 (29%)	914.9 (27.3%)
South 3 (Small)	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.

industries.

Egypt's example may be of relevance to 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.

4. MODALITIES: EVOLUTION FROM IMPORTS TO INDIGENIZATION

4.1. Is Indigenization Necessary? To What Extent? For Whom?

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

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 South 3 which build less than 3 300 MW in 5 years and some countries of South 2 also. However, even in this case, indigenization of auxiliary equipment for transmission and equipment which could be used in other sectors, such as motors, transformers, etc. could be relevant.

Every country has different priorities for different sectors and some countries may find it more worthwhile to go for indigenization of transport equipment, agricultural machinery, machine tools or consumer goods. 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, as discussed in Section 2, whether the power sector has a relative priority over other sectors or not needs to be determined in the overall economic planning.

The most important factor, at the present time, against the domestic manufacturing in the developing countries is the surplus capacity that exists at the global level due to falling demand or zero growth in demand for capital goods for electricity in the western world. One would think that this is a opportunity for North-South trade. Unfortunately, this has not led to a spurt in buying from the developing countries. There are several reasons:

(i) The falling demand in the West has only increased overheads and hence prices of imports by the developing countries as indicated in the changes in the World Bank assumptions made in 1980 (1) and 1982 (8), respectively. Of course, the costs of civil works, etc., 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 dollar since 1982 has only worsened the problem. Even if some prices did not go up in US dollars, there is nearly a 60 percent rise in the value of the dollar itself as measured against the national currencies of most developing countries during this period.

(ii) 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.

(iii) The developing countries of country South 1, which could provide large markets for the North, 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.

Thus, there is a conflict between short-term goals of obtaining the 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 (14).

Taking many factors into account, ranging from surplus capacity, finance, technological constraints, different developing countries may wish to pursue the policies of self-reliance at different levels while cautiously taking into consideration the surplus capacity in the world as well as the relative priorities with respect to other types of capital goods sectors, such as agricultural machinery, transport equipment, consumer goods, etc. However, in all cases there is a need to develop the indigenous capacity to carry out planning and feasibility studies as well as to obtain basic understanding for unpackaging the components of turn-key projects. Even in case of a turn-key import, they should 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.

With these remarks, we proceed to te modalities or steps to gradual indigenization.

4.2. Gradual Steps to Indigenization

It is already shown that there is a gradual transformation in a country's ability to manufacture simple low technology items, such as cables, valves, transformers, etc. to high technology items, such as generators and turbines. From a complete import of turn-key-project-mode, a country could gradually strengthen its capacity to indigenize to the extent possible depending on the demand parameters. These alternative modes may or may not completely 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 develop skills and infrastructure. Relative advantages, constraints and prerequisites for these steps or modes are discussed below. Depending on how it is done, the ordering of these modes may vary. There is much room for better negotiations with the exporters at each step concerning contractual terms which could make a great difference to the importers.

Recalling the distinction made earlier concerning power systems and power projects, it is appropriate to mention the distinction between unpackaging projects and unpackaging technology. The former involves doing the planning and design, feasibility studies, choosing parameters and specifications of different components, assembling and installing hardware, on-site construction etc. Some of this can be done gradually by a team of skilled and trained persons without entering the phase of manufacturing. On the other hand, unpackaging technology refers to understanding the designs and manufacturing of individual components and actually manufacturing them, including the phases of testing and quality control. Thus, the first three steps mentioned below deal with unpackaging projects and the next four steps refer to manufacturing the equipment for power generation as well as transmission and distribution.

4.2.1. Turn-key import from a single source

This mode is pursued by many developing countries of South 2 and South 3 and even South 1, in case of urgent projects. Such a project is often completed with speed and reliability and by a single source, which takes the responsibility of its execution; this naturally involves a high premium for risk factors to recover possible charges that may arise due to failure of any components or sub-contractors. Therefore, it involves significant foreign exchange. The responsible firm subcontracts other firms of their own choice and takes the responsibilities to match all the specifications of different components and exercise quality control. Apart from paying high costs, a country may not always get what is in its best interest, if all the responsibilities are given to others.

4.2.2. Assembling from different sources or from imported parts

This mode requires a competent team of skilled persons who know what is involved in ordering a plant, could match the different components and therefore are in a position to obtain better bargains. However, the responsibility of exercising quality control, risk of failures 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, gradually domestic firms could be encouraged for manufacturing parts.

4.2.3. Foreign subsidiaries

As and when the domestic level of skills and the strength of infrastructure increases, foreign firms may get interested in setting up subsidiaries by bringing capital and technology into the country. They do not, in general, part with the technology but there are many peripheral activities in which domestic talents develop. This provides employment and work-environment for skilled and semi-skilled persons. Moreover, the equipment made by them will, in all likelihood, meet domestic performance requirements because the firms will be first interested in capturing home markets. However, this mode depends upon the economic policies and offers of attractive benefits for encouraging such ventures and the rights of the subsidiaries to repatriate their profits.

4.2.4. Domestic manufacturing under license

As and when the technological infrastructure gets stronger and domestic market expands, the domestic firms get interested in manufacturing equipment themselves - either under license or copying those items which have expired patents. Some low technology items, such as cables, valves, fuses, etc. could be directly made under this mode when direct imports of such small items could lead to delays and involve cumbersome processes. However, for more complex items, this mode can be difficult. In general, this route involves modifications in the design to suit local conditions, which in the case of developing countries could mean high humidity, temperatures, wind, as well as safety against fluctuating voltage and current.

4.2.5. Joint collaboration and ventures

When the technological level in a country goes up, 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. (Depending on the contractual terms involved concerning technology transfer, this mode may or may not be superior to the previous mode.)

4.2.6. Complete indigenization

This involves total disengagement with any foreign firms. This is, of course, not difficult for low and medium technology items but for more complex items, experience with the design and innovation is required and also complete know-how and may require local R+D efforts as well. 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 and the quality difference is minimal.

These alternative modes may have to be considered by the developing countries and their decisions would depend upon the priorities for the equipment, demand levels, technology levels required for manufacturing it and its availability within the country, future expectations for relative cost differences with the imported equipment, etc. However, it should be stressed again that the hierarchy given above could change depending on the terms negotiated. Thus, help in obtaining the best for each mode would lead to productive use of skills and resources of the developing countries.

4.3. Role of Government Policies: Some Examples for Different Modes

The governments of the developing countries often have a stronger role even if they are market economies. Some of the actions by the governments of countries from South 1 are described below 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, even though they may be indirectly relevant. The modes followed by them and their consequences are illustrated below for which (16, 17, 18, 19, 20) are referred.

Brazil, due to its commitment to market economies, allows foreign subsidiaries to enter and compete with the domestic firms (16). It does impose restrictions concerning financial management, i.e. repatriation of profits, imports and exports restrictions, taxes, etc., but it allows them to operate freely as far as technology, patents and innovation are concerned. 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 a 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 forms to be competitive because they compete for the same contracts through tenders but since the domestic firms cannot afford R+D, they are at a disadvantage. Nevertheless, over the years, Brazil has developed manufacturing capabilities of high order and is reasonably diversified. Since Brazil is mainly interested in hydro projects, concentrated efforts are made in hydro-electric equipment. Brazil has the distinction of having built the world's largest Itaipu dam, capable of producing more than 12,000 MW hydro power. It has also taken strides in developing advanced technology in high voltage transmission to carry electricity more than 1000 km afar.

China has repeated older Soviet designs, possibly with some modifications and built up the larges capacity (71 GW in 1981) in the developing countries with 37 percent hydro, 59 percent thermal and the rest in mini-hydro (17). Therefore, China has also diversified like India. It has the indigenous capacity to build 300 MW hydro-plants of 300 MW units and thermal plants with unit size of more than 1000 MW. In fact, it has more than 30 coal-fired mine-mouth stations with capacities in excess of 250 MW. It completed 534 km long 330 kV line in 1975 and 595 km long 500 kV line in 1981.

Thus, several of the achievements of China represent the highest scale that a developing country has achieved. However, China does not have the capability of building nuclear power plants. The thermal power plants are rather inefficient consuming nearly 0.7 tons of coal per 1000 kWh, which is high compared to the values around 0.35 tons per 1000 kWh in the developed countries.

India has gone in for building up capacity to indigenize a whole range of products, where a large part of the low and medium technology items are manufactured in the private sector and the Government's role is in supporting the public sector for high technology items and turn-key projects. It is one of the few developing countries with experience in developing indigenous designs. Moreover, a large domestic market permits the public sector to repeat the same design a number of times prior to moving to the next scale; i.e. from 110 MW to 210 MW and to 500 MW. They have gradually increased the capabilities to the next scale, while attempting to increase exports of lower scale items to other developing countries, as well as continued manufacturing for the domestic use. The licensing and joint venture route has its costs too when antiquated designs are repeated leading to inefficient power plants. This drawback can be corrected by ensuring that new changes in the designs by the parent firms are incorporated in Indian designs. Unlike Brazil and the Republic of Korea, India needs both, thermal and hydro capacity and therefore has to make greater efforts. It is also the developing country most advanced in nuclear technology (11, 18, 20).

The Republic of Korea has gone in for licensing and joint ventures rather than allowing foreign subsidiaries (19). Subsidies are there, but they are time-bound and could be phased out gradually. The government takes an active role in testing and in quality controls by enforcing feedbacks and penalty clauses. However, excess capacity is built up and hence there is competition among domestic firms for which the domestic market is rather limited. Moreover, since the large share of the domestic demand for power is expected to be met with nuclear plants, the experience and the capacity for coal-based thermal power plants would be primarily for export purposes. Unfortunately, this happens at a time when there is a surplus capacity even in the developed countries resulting in a strong global competition for export markets which would again call for government help if Korea is to face this competition.

Mexico has reservations about subsidiaries operating in this field, because domestic firms and institutions do not benefit from them. Therefore, Mexico prefers joint ventures, the majority of which are with US firms (14).

The concept of power systems as opposed to manufacturing components is relevant here. Such experiences are more with the larger countries like Brazil, India, China, rather than Korea, Singapore, etc., partly because of domestic experience.

5. 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 approach will be required for manufacturing capital goods and for energy development in general. These aspects are discussed in this section as summarized from (10).

In addition, issues related to the requirements of specific country groups need to be addressed too. 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 specially committed for that group alone.

5.1. Engineering Services for Energy Development

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

(i) Prior to commissioning a project: 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 case of exploration, the reliable services for locating and siting are as important as the equipment or more. 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 called for.

(ii) Constructing a project: These require services for which partial use of local services could be made, especially for constructing buildings, dams, making roads, laying railway lines to move coal or digging for laying pipelines. The components of local labor 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 requiring 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.

5.2. Backward and Forward Linkages

These linkages are illustrated in Figure 2. Since the forward linkages with the utilizing sectors, which determine the need for electricity and hence the 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, wind, etc.). But the next concern is the availability of components and then the availability of the raw materials for power equipment. This will help in analyzing the import vs. manufacturing issues with respect to power industries. The major raw materials required for manufacturing 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 Table 6, the data reported by Bechtel (21) for constructing some of the energy 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 of 500 MW. Therefore, the required raw materials for an actual 100 MW plant may be higher than those indicated in Table 6.

Table 6. Material requirements in 10^3 tons for 100 MW power plants

Facility Name	Unit	Carbon Steel	Low Steel Alloy	Stain-less Steel	Total Steel	Copper	Alumin-ium	Con-crete	Cast Iron
Power:									
1. Oil-fired power plant	100MWe	1.76	0.138	0.044	1.942	0.064	0.015	10.7	0.03
2. Coal-fired power plant, low Btu	100MWe	2.6	0.18	0.044	2.824	0.13	0.03	17.5	0.05
3. Low/intermediate Btu gas-fired plant	100MWe	0.9	0.087	0.02	1.	0.048	0.01	6.26	0.02
4. Gas turbine power plant	100MWe	0.3	0.022	0.006	0.5	0.021	0.005	1.57	0.01
5. Light water reactor	100MWe	4.3	0.43	0.182	5.	0.207	0.06	50.76	0.08
6. Dam and hydroelec. power plant	100MWe	5.8	0.144	0.017	6.	0.138	0.34	75.	0.23
7. Pumped storage	100MWe	4.1	0.071	0.01	4.18	0.07	0.016	58.8	0.005
8. 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 (1)). Since the scale of the facilities in the USA is larger, the scaling down to small facilities of 100MWe etc. may indicate smaller requirements than actually necessary.

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 less than those needed by coal plants. Geothermal power, on the other hand, requires more steel but not much cement. The plant that requires the last materials is the latest gas-turbine technology.

In general, 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 regions in the world total are rather small. Figure 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., while auxiliary equipment of low and medium technology can be still made without the processing technology, the main equipment, i.e. boilers, turbines, etc., would require such a technological infrastructure.

5.3. Energy 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 be almost made in the rural areas, except pipes for transporting gas, good quality burners and the gas holders which 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.

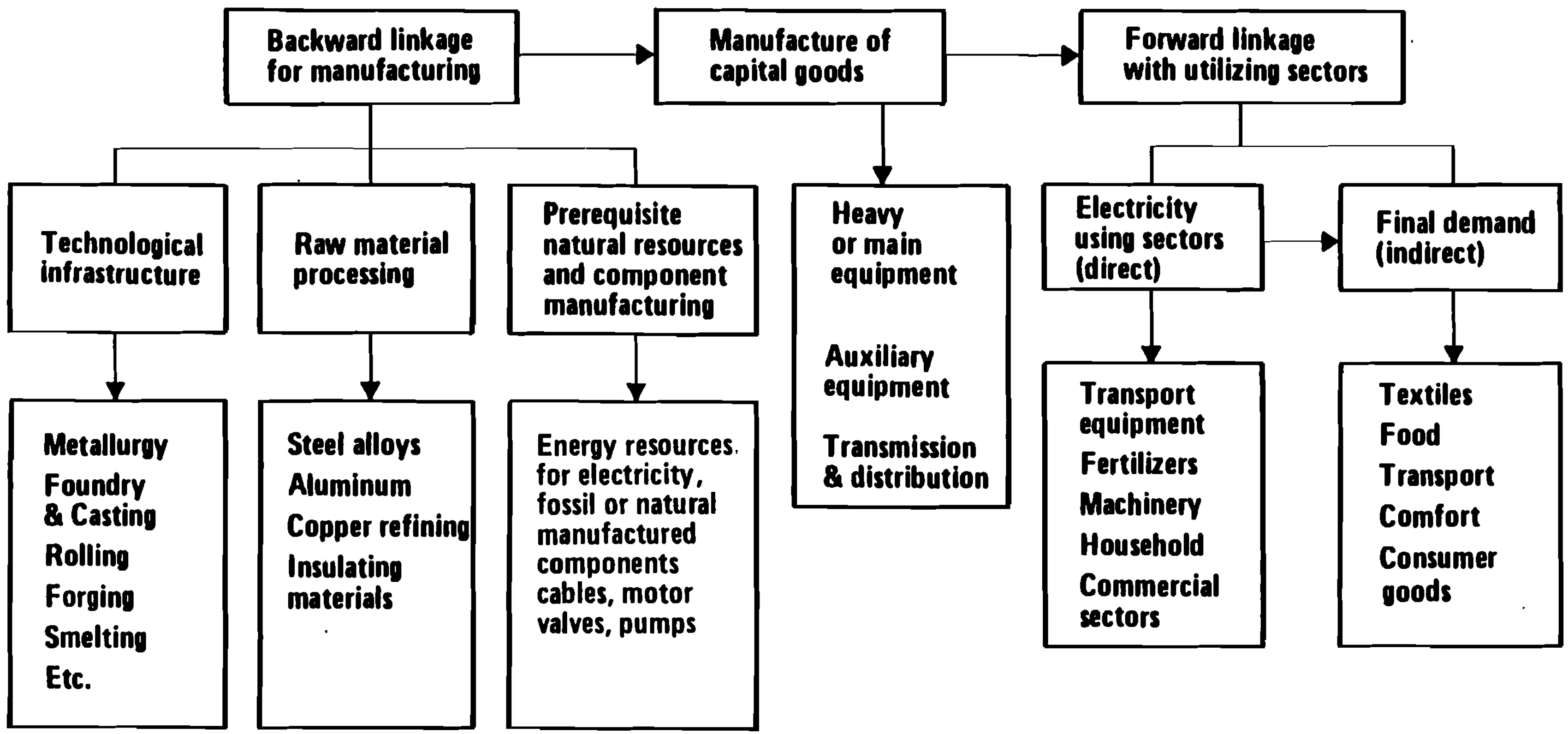

Figure 2. Backward and forward linkages essential for manufacturing power equipment

- 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 taped 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 do not include high technology items.

However, there are two conditions which require to be fulfilled for successful 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 meters 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 case of NRSE, these investigations have to be done many times over for equivalent amount of energy. Thus, it would require spread of skills of a different nature 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 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 bigger computers stopped and turned to small but large *number* of computers spreading the computing power to many persons. But new organizations and ways of working are not yet developed.

6. HIGHLIGHTS AND IMPLICATIONS

This article focusses on structural changes that have taken place in the e.c.g. industries recently and the need for the necessary reorientation. The major structural changes that took place in the Seventies are:

- Sharp decline in the North in the energy demand and therefore the demand for e.c.g. and moderate decline in the demand in the South for energy and e.c.g.
- Composition of the energy demand has changed requiring less imported oil, but increased investment in oil and gas exploration, hydro-electricity, etc.
- Volumes of trade have dramatically increased in the last four years signifying a major price increase. This increase is 2- to 4-fold, especially in high technology items.
- Shares of the developing countries in the world imports have significantly increased.

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

In 1980, developing countries spent nearly 25 billion US dollars to import capital goods for the energy sector, as against 34 billion dollars to import crude oil. (In addition, nearly 10 billion dollars were spent for petroleum products, part of which are imported from the developed countries.) Some of the individual developing countries spend for the energy-equipment as much as that for importing crude oil and oil products. Thus, imports of capital goods for development of energy industries and imports of oil are both competing for scarce foreign exchange for the energy sector, but the former which is essential to build up the nations, has not received as much attention of the media and of 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 claims often the largest share of public investment, even more than agriculture, industries or transport, of which power industries claims nearly 60% to 90% investment especially in non-OPEC countries. The importance of power in the total investment is mainly due to its capital intensiveness and due to backlog in power development (and also due to the fact that imports bill of oil 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) "Big" 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 a few items and even in a position to export, although presently this export is at a very low level.

(d) Medium and small size countries:

Nearly thirty developing countries have individually moderate requirements of 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 more 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 continue to 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 which is unnecessary in any case for labelling all items individually. It enables us to identify general patterns.

(e) 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 required by even 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.

(f) Prognosis for country groups:

As and when developing countries industrialize, their ability to manufacture and export will increase especially in low and medium technology items. Excluding a few items, it would be some time 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 these items also bear this out. For example, during 1967-1978, the prices of high technology items have increased five to six-fold, but those of medium and low technology items 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. Much price increase seems to have taken place during 1977-78.

(g) The shares of e.c.g. exporters, namely EEC:USA:Japan in the world export are roughly 55:13:14. These shares have not changed much in the last decade with the exception of rising shares of Japan at the cost of the US share. In value terms, the e.c.g. industries have shown annual growth of 18% during the 1976-80.

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

Over the last two decades, North has built up more capability of manufacturing capital goods than it would need to use in the present circumstances of high oil prices which has led to conservation measures and hence to reduced energy consumption. In principle, in a cooperative world, the developing countries need not duplicate these efforts and could use this idle capacity. However, in practice, the prices of capital goods are increasing compelling them to increase their own manufacturing, by at least those countries who have 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 the overcapacity in the world oil production and refining at the present time. Presently, the North could cooperate directly with South 1 due to somewhat identical nature of demand (in terms of scale) of capital goods especially in high technology items. South 2 (medium) countries have moderate demand individually, but together they import more capital goods than South 1 (big) countries; in 1978, 29 countries of South 2 nearly spent 12 billion dollars compared to 6 billion dollars by seven countries of South 1. However, the e.c.g. industries in the North would require reorientation to cater to their demand because they would require items for smaller facilities than these prevalent in the North or 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.).

(i) 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. Evenso, the capital goods for conventional commercial energy options would remain major components of the imports for the energy sector till at least the end of the century and perhaps beyond.

Example of hierarchy of SITC classification used for trade of all items

In the following hierarchy of trade classification, at each successive digit, the disaggregation increases keeping the first n-1 digit constant for n-th digit level items. The following example will make it clear (it corresponds to revision 1).

SITC No. Description

One-digit level

7 All manufacturing

Two-digit level

77 Total electric machinery

Three-digit level

771 Non-electric power generating equipment (high technology):

Non-electric steam generating boilers including related items such as superheaters, condensers, etc. Although steam boilers could be used in other industries as well, their percentage is expected to be small (10% in case of India).

772 Electric circuit apparatus

Four-digit level

7711 Steam boilers

7713 Steam turbines

7722 Switch gears

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