OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

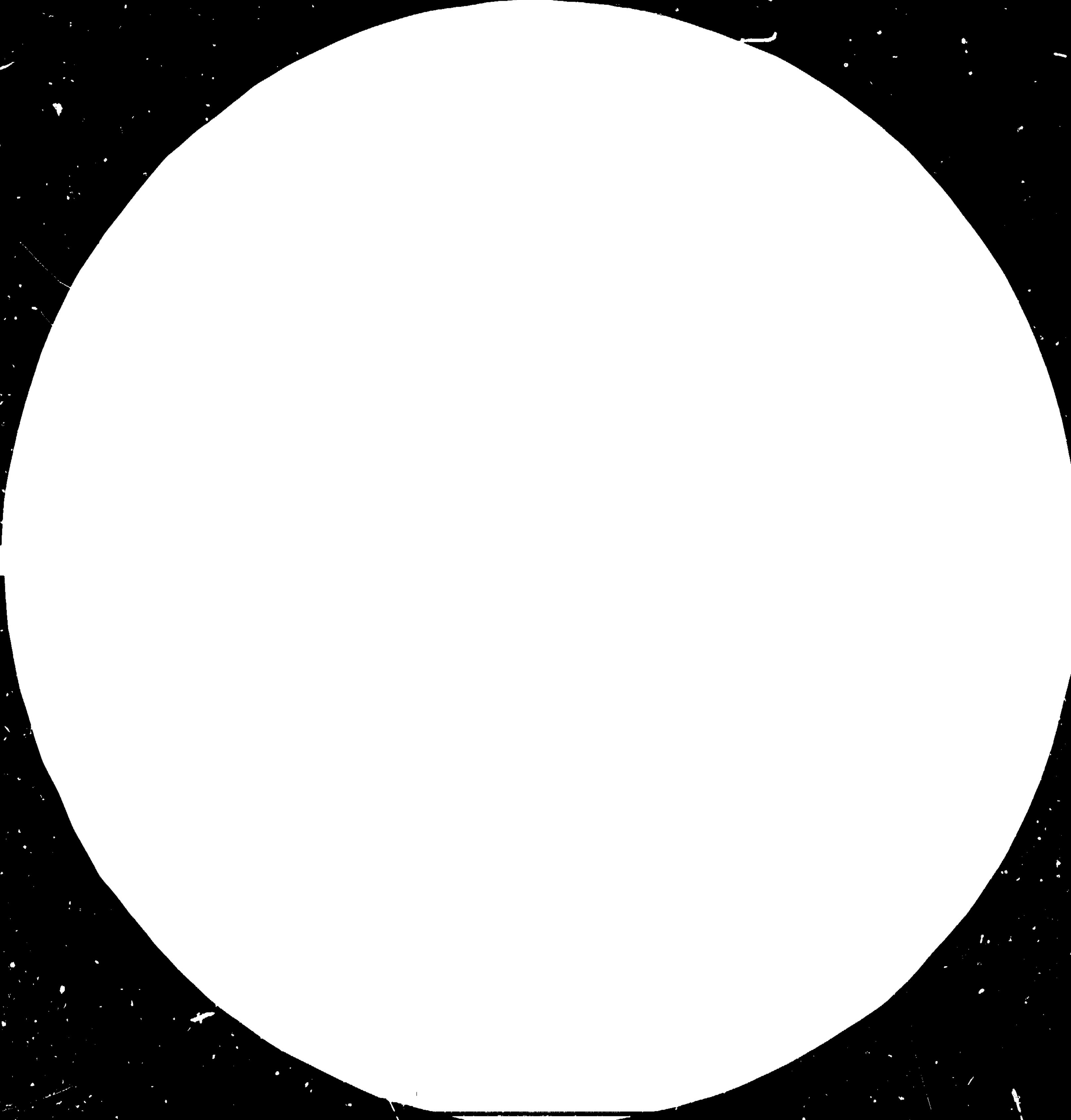
FAIR USE POLICY

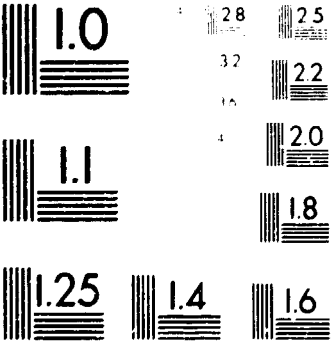
CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

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





MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS
STANDARD REFERENCE MATERIAL 1010a
(ANSI and ISO TEST CHART No. 2)

Distr.
LIMITED
UNIDO/IS.509
18 January 1985
ENGLISH

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

14326

ELECTRIC POWER EQUIPMENT PRODUCTION IN DEVELOPING COUNTRIES: A TYPOLOGY AND ELEMENTS OF STRATEGY

Sectoral Working Paper Series

No. 26

R. Tiberghien
P. Vernet

Sectoral Studies Branch
Division for Industrial Studies

V.85-20969

10

SECTORAL WORKING PAPERS

In the course of the work on major sectoral studies carried out by the UNIDO Division for Industrial Studies, several working papers are produced by the secretariat and by outside experts. Selected papers that are believed to be of interest to a wider audience are presented in the Sectoral Working Papers series. These papers are more exploratory and tentative than the sectoral studies. They are therefore subject to revision and modification before being incorporated into the sectoral studies.

This paper is largely based on work undertaken by Mr. R. Tiberghien and Mr. P. Vernet of the Institut de Recherche Economique et de Planification du Développement, Grenoble, France. The views expressed do not necessarily reflect the views of the UNIDO secretariat.

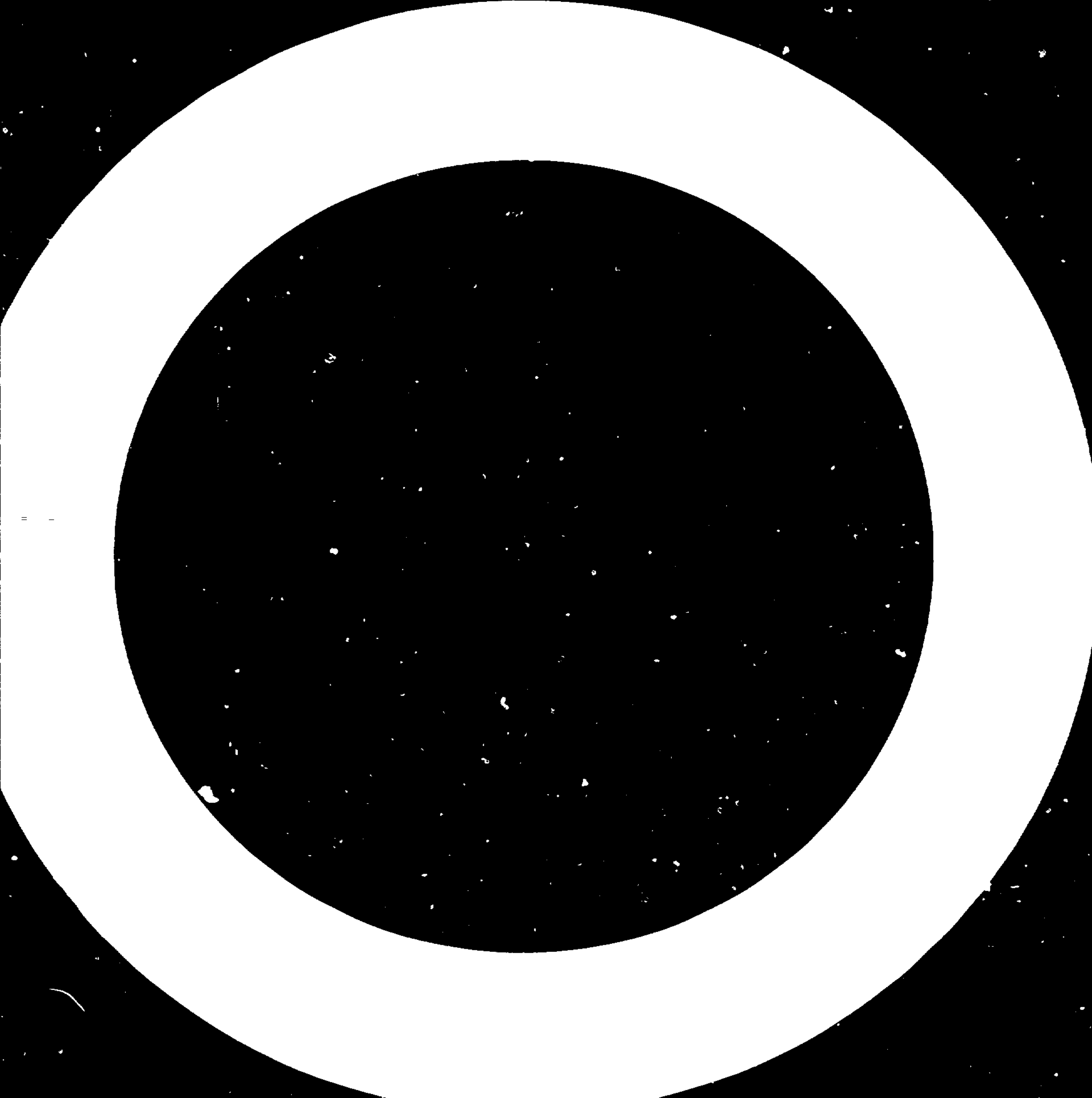
Preface

This study has been prepared at the request of the Sectoral Studies Branch, Division for Industrial Studies, UNIDO. Its purpose is to provide the basis for an examination of the strategies for the establishment and development of the manufacture of equipment for the generation, transmission and distribution of electricity in developing countries.

The typology consists of a classification of countries in homogenous groups from the point of view of their potential market and their technical capacity for the production of capital goods. There are many risks entailed in the establishment of any typology or any classification. However, on the other hand it is not possible to be content with a global and undifferentiated analysis not taking into account the differences in various aspects between countries. The proposed typology should not be considered as a strict classification but only as an attempt at bringing some order into the discussion.

The typology is described in the first part of the study. Seven groups of developing countries have been identified. For each of the groups, strategy elements have been worked out on the basis of a set of country case studies undertaken by UNIDO. That constitutes the second part of the study. The study should be used in conjunction with "Electric power equipment production in developing countries: Options and strategies. An analysis of eleven country case studies" (UNIDO/IS.507).

The description and analysis presented in this paper is largely based on work undertaken by Mr. R. Tiberghien and Mr. P. Vernet of the Institut de Recherche Economique et de Planification du Développement, Grenoble, France.



Contents

Tables

Tables

Figures

EXPLANATORY NOTES

References to dollars ($) are to United States dollars, unless otherwise stated.

A comma (,) is used to distinguish thousands and millions.

A full stop (.) is used to indicate decimals.

A slash between dates (e.g., 1980/81) indicates a crop year, financial year or academic year.

Use of a hyphen between dates (e.g., 1960-1965) indicates the full period involved, including the beginning and end years.

The following forms have been used in tables:

Three dots (...) indicate that data are not available or are not separately reported.

A dash (-) indicates that the amount is nil or negligible.

A blank indicates that the item is not applicable.

Totals may not add up precisely because of rounding.

Besides the common abbreviations, symbols and terms and those accepted by the International System of Units (SI), the following abbreviations and contractions have been used in this report:

Economic and technical abbreviations

CKD	Completely knocked down
GDP	Gross domestic product
GNP	Gross national product
ISIC	International Standard for Industrial Classification
MVA	Manufacturing value added
NICs	Newly industrializing countries
R & D	Research and development
SITC	Standard International Trade Classification

1. INTRODUCTION

Electric power equipment[1/] for the production, transmission and distribution of electricity can play an important part in the industrialization process of a developing country. Electrification of a country is a means to create at one and the same time favourable conditions for industrial development and an improvement of the population's living conditions. Moreover, rural electrification, considered specifically, helps to halt the rural exodus by giving the rural population access to the same living conditions as the urban population. It also makes it possible to encourage the emergence of small-scale industries and their better distribution throughout the country. It is, therefore, understandable that the majority of developing countries give high priority to electrification programmes, including rural electrification.

With the notable exception of mini hydro plants, decentralized alternative electricity production technologies, on which much hope was set some years ago, lead to high costs of production. Table 1 illustrates by a typical example of village electrification the orders of magnitude of the total cost of production of electricity delivered to the user, by reference to various options. These options are based on the following chief hypotheses:

(a) 200 domestic subscribers, production activity (local industry, irrigation) providing demand in slack periods; consumption: 150 MWh/yr domestic, 500 MWh with production activity.

(b) Fairly high population density; cost of distribution network $US 90,000.

(c) Locally available resources for all the technological variants envisaged; in practice, this hypothesis would be unrealistic, but it makes theoretical comparisons possible in this context.

(d) Personnel costs $US 5,000 per person and year, interest rate 8 per cent per annum.

1/ In this paper, electric power equipment is taken to mean the products in major groups 71 and 77 of SITC (Rev.2); nuclear power equipment has been excluded; see Report of UNIDO Expert Group Meeting on the Energy-related Equipment and Technology, Vienna, 19-21 December 1983, UNIDO/PC.87.

Table 1. Comparison of the costs of electrification of a village by reference to several technological variants

Option	Cost of production $US/kWh
Interconnection from a network situated 50 km to the village to be electrified Investment: $450,000, 2 persons, annual maintenance $3,000, 500 MWh/yr, maximum power 100 kVA, $0.04/kWh of medium voltage power	0.16
Diesel generator set Investment: $200,000, 5 persons, annual maintenance costs $5,500, 500 MWh/yr, maximum power 100 kVA, $0.5/litre of diesel fuel	0.26
Photovoltaic cells Investment: $1.95 million, 2 persons, annual maintenance costs $8,000, 150 MWh/yr, maximum power 100 kVA, energy: free	1.48 a/
Wind generator Investment: $900,000, 3 persons, annual maintenance costs $13,000, 150 MWh/yr, maximum power 100 kVA, energy: free	1.03 a/
Mini hydro power station Investment: $350,000, 5 persons, annual maintenance costs $60,000, 500 mWh/yr, maximum power 100 kVA, energy: free	0.10
Diesel generator fed by lean gas from wood pyrolysis Investment: $230,000, 5 persons, annual maintenance costs $6,000, 500 MWh/yr, maximum power 100 kVA, $0.1/kg of wood	0.22

a/ Electricity cannot be provided for use in local manufacturing.

Source: P. Vernet, Evaluation de filières technologiques pour l'électrification rurale (Evaluation of technological routes for rural electrification), internal document, IREP, August 1982, 40 pages.

Electrification today is pursued in all countries on the basis of the classical solution, namely, by connecting medium voltage lines to a grid. Local networks supplied by mini hydro power stations can be set up provided that there is a river with an adequate volume of flow at low level such as e.g. some Andean countries in Latin America. Whatever solution is adopted, electricity supply requires a very considerable investment. Futhermore, the costs of production (price per kWh at the power station terminals) represent only a limited part of the total cost per kWh to the user (less than half and sometimes even less than 20 per cent in rural areas). This is due to the high investment needed for electricity transmission (high voltage) and distribution (medium and low voltage).

Even if a developing country is unable to produce the key element in a power station - the turbo-alternator - the local production of equipment requiring less complex technologies such as pylons and poles, cables, insulators, distribution transformers, etc. can very significantly reduce the foreign exchange component of capital investment for electricity.

Furthermore, the production of electric power equipment requires conducting engineering studies and the development of mechanical engineering capacity. The production of capital goods and electric power equipment is therefore part of the process of the mastering of technology.

Domestic production of electric power equipment must be encouraged in the developing countries in view of:

(a) The priority accorded to electrification programmes;

(b) The fact that even production of simple equipment for distribution has a significant impact on the foreign exchange balance of these programmes;

(c) The leading role of the capital goods industry in the process of industrialization and mastering of technology.

2. THE NEED FOR A TYPOLOGY OF DEVELOPING COUNTRIES

The main purpose of this paper is to assist the developing countries in working out industrial policies and strategies to create or develop an electric power equipment industry.

In view of the different levels of industrial development achieved by the developing countries, ranging from the least developed countries to the newly industrializing countries, a differentiated approach is required. In some of the countries there is no capital goods industry so that it will be necessary to consider a strategy for starting up the industry. In other countries, the national capital goods industry produces the full range of equipment; there it will be a question of consolidating the industry and of enabling it to produce the most sophisticated types of equipment and/or give it access to advanced technology; vacuum or sulphur hexafluoride (SF_6) circuit-breaking for switchgear, for example. Between these two extremes, one can find almost all levels of development of this industry. It is beyond the scope of this paper to deal with every country individually. Therefore, the countries are grouped according to their potential to develop the electric power equipment industry.

At the world level, the electric power equipment industry is often regarded as an oligopoly or as a cartel.2/ This view cannot be held in the case of simpler equipment, the technology for which has been mastered in a large number of medium-sized companies in the industrialized countries and in a growing number of developing countries. In this case, the respective bargaining capacities of the owner of technology and the developing country wishing to obtain it are very different from the oligopoly case. A typology of developing countries must, therefore, also make it possible to take into account the different bargaining conditions for the transfer of technology.

2/ See A. Gaulé, Analyse des stratégies des acteurs dans le secteur des biens d'équipement électrique (Analysis of strategies in the electrical capital goods sector), December 1983. Study prepared for UNIDO, Université des Sciences Sociales de Grenoble.

As a general rule, the difficulties of negotiating a transfer of technology increase with the technological complexity of electric power equipment. This, in a sense, is favourable, since the developing countries with a low level of industrialization will negotiate for simpler technologies that are more easily available. It will be the most advanced developing countries that will negotiate the transfer of more complex technologies; these countries are those that have the strongest bargaining power.

By grouping the developing countries it will be possible to prepare strategies for the development of the electric power equipment industry which:

- Will take into account the differences in the industrialization level of the countries.

- Are linked to the technological complexity of the products whose manufacture is envisaged.

- Evaluate the country's bargaining power for the transfer of technology according to the structure of the electrical industry at world level.

2.1 Guiding principles for preparing a typology

The existence of a certain degree of correlation between the per capita production of electricity and the per capita gross national product is illustrated in figure 1. The per capita production of electricity and the total value added in the mechanical engineering and electrical engineering industries also seem to be linked (see figure 2). One might thus be tempted to construct a typology on the basis of a regression analysis of various statistical indicators.

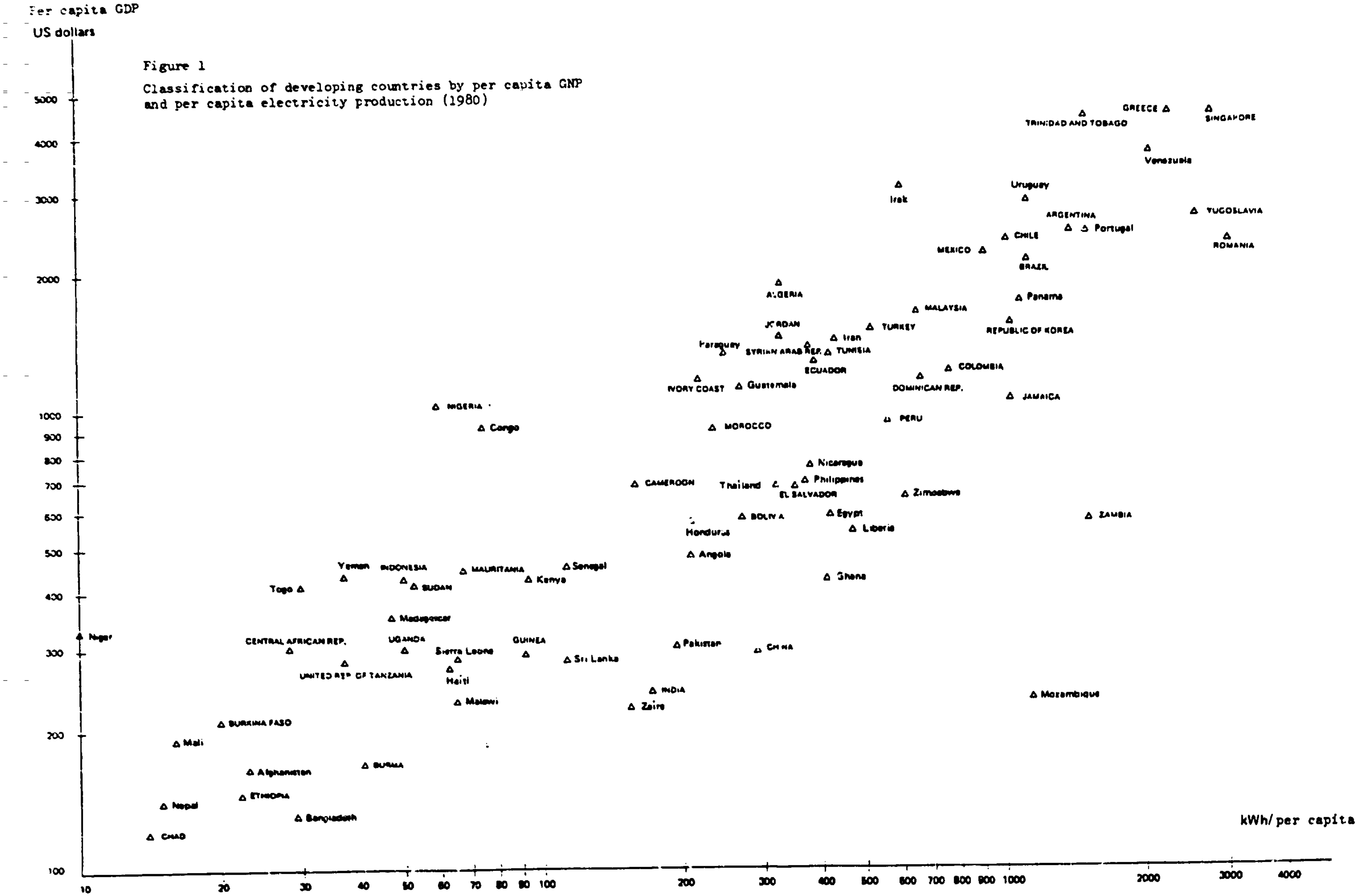
This method was not selected for several reasons; mainly because statistical indicators that are sufficiently reliable and available for a large number of countries are rare.[3/] Furthermore, tentative correlation

---

3/ See the discussion in point 2.4 on the indicators selected.

Figure 1

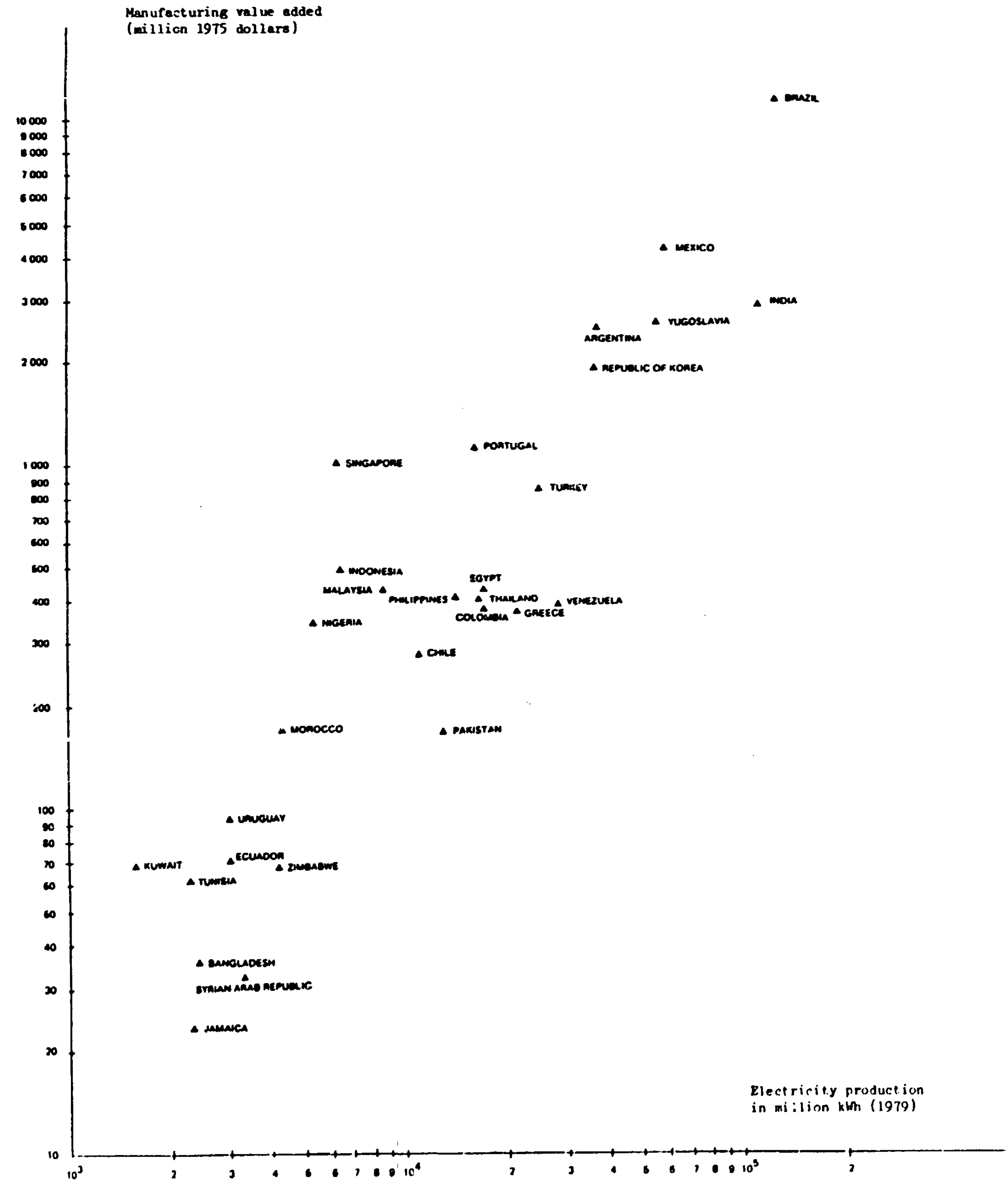
Classification of developing countries by per capita GNP and per capita electricity production (1980)



Logarithmic scales
Source: World Bank, Business International

Figure 2

Classification of developing countries by mechanical and electrical engineering production (ISIC 7) and electricity production (1979)



Logarithmic scales

Source: World Bank, Business International calculations that were made did not show interesting results with regard to significant groupings on the basis of the indicators chosen. More fundamentally, a regression analysis is not necessarily in conformity with the purpose of the work. In fact, the results that are likely to appear, could be interpreted as follows:

(a) Within an identified group of countries, the development process would be almost automatic: the countries situated at the bottom of the curve, (surface or volume)[4/] would develop towards upper positions even in the absence of any industrial policy.

(b) The statistical relationships within the identified groups would not allow conclusions on how the countries situated at the top would develop or whether it is possible to pass from one group to another.

Groupings made on a purely econometric basis would not appear to facilitate the elaboration of industrial strategies. Therefore, no attempt will be made to prepare a typology of the developing countries on this basis. Nevertheless, relevant statistics will be used and presented in the following.

2.2 The methods used to prepare the typology

2.2.1 Countries selected

The statistics published by the World Bank, which are the most complete for the purpose of this paper,[5/] cover 92 countries with more than one million inhabitants. It will be shown later that smaller countries may adopt strategies similar to those of the smallest countries covered by the statistics.

4/ A curve with two indicators is used in the analysis, a surface with three indicators and a volume with four or more indicators.

5/ Other data were also used, see section 2.4.

For 13 countries, however, statistical information is inadequate and it will not be possible to classify them. These are: Benin, Bhutan, Burundi, Democratic Kampuchea, Democratic Yemen, Laos, Lesotho, Mongolia, Niger, Papua New Guinea, Rwanda, United Arab Emirates and Viet Nam. With some exceptions, these countries are small in size and at a relatively low level of industrialization. Of the 92 countries with more than one million inhabitants covered by the World Bank statistics, 79 will, therefore, be dealt with in our typology.

2.2.2 Methods and criteria adopted

Having discarded a purely econometric approach, a multi-criteria classification has been adopted, taking into account particularly:

(a) The size and development potential of the domestic market for electric power equipment;

(b) The potential industrial capacity for commencing the production of electric power equipment.

The indicators selected to evaluate the market for electric power equipment are: the total population of the country, per capita electricity production and present imports of electric power equipment.

The choice of the first indicator, total population, is obvious and does not require any long discussion.

The per capita production of electricity[6/] reflects with some exceptions[7/] a country's degree of electrification. However, countries with a large-scale industry, which is a heavy consumer of electricity (e.g., the aluminium industry), will, with an equal per capita consumption, need less

---

6/ In the absence of information on consumption, which was not available.

7/ Countries that export electricity, particularly hydroelectricity.

equipment for transmission and distribution than the average. Since no developing country has reached the saturation point beyond which consumption and production increase only very slightly, it is justified to consider that the demand for more and more complex electric power equipment will grow with the degree of electrification.

Imports of electric power equipment constitute the last indicator for identifying the market. There again, experience shows that these imports continue to grow as the degree of electrification increases, even if there is already considerable domestic production. This may be linked to emerging export possibilities for certain types of equipment combined with demand increases for large-scale equipment and/or equipment embodying more sophisticated technology.

Industrial capacity and the potential for setting up the manufacture of electric power equipment are measured by the value added in all the metal working mechanical and electrical engineering industries. The level of complexity of the technologies used, the qualifications of labour necessary are close to one another in these industries. Moreover, it is known that links may be established, particularly between the mechanical and electrical engineering industries. This is therefore probably the set of industries that can best reflect a potential for starting or developing the production of electric power equipment.

To sum up, the classification of the countries will be based on four indicators:

- Population;
- Per capita production of electricity;
- Imports of electric power equipment;
- Value added in the metalworking, mechanical and electrical engineering industries.

The first three are related to the market for electric power equipment and the fourth to industrial potential for their production.

2.2.3 Alternative criteria considered

Several other indicators that seemed interesting at first sight, had to be discarded for various reasons.

Value added in the electric power equipment industries would have best reflected the present situation of industry. Unfortunately, this information is not available except for a small number of countries. The classification of 79 countries would therefore not have been possible.

Export figures for capital goods or electric power equipment might have made it possible to identify better the equilibria existing in the markets, by relating them to national production and imports. However, today only the newly industrializing countries have significant exports of electric power equipment. In the other cases, exports of capital goods - particularly electric power equipment - with some exceptions, do not attain significant values. Thus this indicator, although often available, was not selected.

The value of manufacturing gross domestic product (absolute or per capita) is also available in most cases, at least through estimates of the structure of total GDP. However, production of manufacturing industry as a whole seems to be a less precise tool for identifying capacities and potential of the electric power equipment industry than value added in the mechanical and electrical engineering industries, which was finally selected.

A country's rate of urbanization might be an interesting indicator, as it would indicate the direction in which electrification might develop. In a predominantly rural country, it would be necessary to orient the production of electric power equipment more towards products intended for rural electrification. However, it will be seen that the use of the four criteria selected separates implicitly predominantly rural from predominantly urban and industrial countries. Therefore, use of this indicator would scarcely have improved the classification made. In fact it would have been redundant.

Gross fixed capital formation reflects a country's capacity to invest; which is a relevant factor in the present context. However, one must remember that investment figures as included in available data on gross fixed capital formation go far beyond productive investment; the construction of housing and infrastructure are e.g. included in gross fixed capital formation, but quite far removed from the capacity for starting production of electric power equipment.

Some financial statistics could also be selected. Balance of payments data may give an indication of the capacity for financing industrial investment but would require detailed supplementary information in order to be interpreted correctly.

All the data discussed above are useful for formulating a policy for a given country. However, they have not been selected for the elaboration of the typology since:

(a) The necessary statistics are not available for many countries; or

(b) Supplementary information would be required in order to interpret the data in a simple and reliable manner.

The four statistical indicators selected will make it possible to define seven groups of countries for which different strategies for the development of domestic production of electric power equipment can be formulated.

2.3 The identification of potential market and production capacities

2.3.1 Principles for the choice of indicators

The selection of indicators will depend on the purpose of the typology . In this case the typology is neither intended to explain the past development nor to be a basis for quantified forecasts. Instead it should be relevant for developing countries with regard to:

(a) Their potential capacity for starting or developing the production of electric power equipment.

(b) Their market in actual and potential terms.

The word "potential" is used in its true meaning and should be distinguished from "actual". We have chosen an indicator of the potential and not of the actual capacity for starting or developing the production of electric power equipment, namely the value added in the mechanical and electrical engineering sector. The actual, or real, capacity depends on industrial strategies, on the number of available engineers and technicians, on the past growth rate of the sector, etc.

In the same way, indicators of a potential and not of an actual market were chosen, namely:

- Population;
- The electrification rate;
- Imports of electric power equipment.

The size of the real market depends on the financing capacity, the electrification programme, etc. for which no suitable indicators are available.

To sum up: this approach is made in terms of potential and not in actual terms, making possible a relative (but not an absolute) grouping of developing countries in relation to one another according to:

(a) Their potential capacity for commencing or developing the production of electric power equipment.

(b) Their potential market.

2.3.2 Interdependency of selected indicators

While the variables population and electricity production can be considered as independent variables, the same does not apply to imports of electric power equipment and value added in the engineering industries, both of which can be interpreted as functions of population and electricity production. However, it will be recalled that the object is not to elicit econometric laws; in this case, it would indeed be necessary to look for indicators which are genuinely independent; however, in this paper, which aims to group countries on the basis of criteria of potential, the use of interdependent variables does not constitute an obstacle - it serves rather to refine the analysis.

2.4 Results

2.4.1 Presentation of basic indicators

The following data were collected for 79 countries with more than one million inhabitants:

(a) Their rank according to size, following World Bank statistics (World Development Report, 1983).

(b) Population (in million inhabitants in 1981); source: World Bank.

(c) Annual per capita production of electric power (kWh per capita) on the basis of the total electricity production provided by the Business International publication (World-wide Economic Indicators, 1983).

(d) Imports of electric power equipment (1981, SITC Rev.2, Groups 711, 714, 716, 771, 772 and 773); source: Statistical Bulletin of World Trade in Products of the Mechanical and Electrical Engineering Industries, United Nations Economic Commission for Europe, 1983.

(e) Value added in the sector of mechanical and electrical engineering industries (1981, ISIC, Division 38). For the vast majority of countries this value is calculated either from the World Bank figures (table 3 of the 1983 World Development Report to obtain manufacturing output and table 6 to obtain output in the machinery and transport equipment sector from manufacturing output) or from the United Nations document: Yearbook of Industrial Statistics, 1980. In the case of countries for which the information is not available (African countries), estimates were made. In certain cases, the position of the country was estimated only in terms of the five classes selected (see page 20-25).

Table 2. Basic indicators for the typology

Name of country	Rank (1)	Population (2)	Per capita electricity production (3)	Imports of elec.power equipment (4)	Manufacturing value added (5)
Units	-	million	kWh/yr	$ million	$ million
Afghanistan	9	16	61	7.4	C_1 (e)
Algeria	80	20	310	345	460 (e)
Angola	50	8	190	29	50 (e)
Argentina	84	28	1,450	280	10,340
Bangladesh	5	91	29	34	40
Bolivia	43	6	250	29	50
Brazil	81	120	1,145	659	15,930
Burma	8	34	41	51	C_2 (e)
Cameroon	56	9	144	under 50 (e)	C_2 (e)
Central African Rep.	26	2	30	under 50 (e)	5
Chad	4	4.5	13	under 50 (e)	7
Chile	85	11	1,080	121	1,380
China	21	991	310	445	C_5 (e)
Colombia	66	26	790	193	830
Congo	58	2	50	under 50 (e)	C_1 (e)
Costa Rica	68	2	1,10	35	50
Cuba	57	10	1,030	69	C_3 (e)
Dominican Republic	64	6	570	42	10
Ecuador	61	9	360	62	150
Egypt	46	43	430	414	600 (e)
El Salvador	47	5.1	320	15	35
Ethiopia	6	32	22	14	10
Ghana	34	12	400	20	75
Guatemala	59	7.5	260	27	C_2 (e)
Guinea	22	6	83	under 50 (e)	C_1 (e)
Haiti	23	5.1	80	21	C_1 (e)
Honduras	44	4	200	16	4.4
India	17	690	170	327	C_5 (e)
Indonesia	41	150	47	374	710
Iran	75	40	430	403	C_4 (e)

Table 2. Basic indicators for the typology (cont'd)

Name of country	Rank (1)	Population (2)	Per capita electricity production (3)	Imports of elec.power equipment (4)	Manufacturing value added (5)
Units	-	million	kWh/yr	$ million	$ million
Iraq	76	13.5	590	1,080	C_3(e)
Ivory Coast	63	8.5	210	under 50 (e)	150
Jamaica	62	2	1,150	under 50 (e)	C_2(e)
Jordan	72	3	370	112	30
Kenya	35	17	94	under 50 (e)	110
Dem. Rep.of Korea	69	19	1,840	18	C_3(e)
Rep. of Korea	74	39	1,030	721	3,130
Kuwait	97	1.5	6,200	528	40
Lebanon	79	3	600	57	C_2(e)
Liberia	40	2	450	under 50 (e)	C_1(e)
Libya	95	3	1,030	700	C_2(e)
Madagascar	28	9	44	12	C_1(e)
Malawi	11	6	67	5.3	10
Malaysia	77	14	640	330	750
Mali	10	7	14	under 50 (e)	15
Mauritania	37	1.6	63	under 50 (e)	C_1(e)
Mexico	82	71	904	1,250	9,990
Morocco	52	21	220	91	240
Mozambique	31	12	1,120	14.5	C_2(e)
Nepal	7	15	15	under 50 (e)	C_1(e)
Nicaragua	53	3	330	6.5	25
Nigeria	54	88	57	570	550
Pakistan	30	85	200	106	C_4(e)
Panama	78	2	550	25	10
Paraguay	73	3	270	12	72
Peru	60	17	580	83	580
Philippines	49	50	320	247	970
Saudi Arabia	96	9	1,000	2,340	C_3(e)
Senegal	36	6	117	under 50 (e)	40
Sierra Leone	27	3.6	56	under 50 (e)	C_1(e)
Singapore	93	2.4	2,920	506	2,070

Table 2. Basic indicators for the typology (cont'd)

Name of country	Rank (1)	Population (2)	Per capita electricity production (3)	Imports of elec.power equipment (4)	Manufacturing value added (5)
Units	-	million	kWh/yr	$ million	$ million
Somalia	18	4.4	18	under 50 (e)	C_1 (e)
Sri Lanka	24	15	127	51	80
Sudan	32	19	53	31	C_2 (e)
Syria	71	9	490	100	C_3 (e)
Tanzania	19	19	37	under 50 (e)	C_2 (e)
Thailand	48	48	313	157	C_4 (e)
Togo	33	3	27	under 50 (e)	C_1 (e)
Trinidad & Tobago	94	1.2	1,500	30 - 500 (e)	80
Tunisia	67	6.5	415	94	90
Turkey	70	45	560	335	1,610
Uganda	13	13	54	under 50 (e)	C_2 (e)
Upper Volta (Burkina Faso)	15	6	17	under 50 (e)	10
Uruguay	88	3	1,100	22.3	280
Venezuela	89	15	2,070	451	820
Yemen Arab Republic	38	7	36	under 50 (e)	C_1 (e)
Zaire	12	30	150	53	C_1 (e)
Zambia	45	6	1,480	15	70
Zimbabwe	55	7	640	17	160

(1) Classification by per capita GNP 1981 in ascending order. Source: World Bank, World Development Report, 1983.

(2) Population at mid-1981. Source: World Bank, ibid.

(3) From electricity production 1981. Source: Business International, World-wide Economic Indicators, 1983.

(4) 1981 figures. Source: United Nations, ECE, Bulletin on world trade statistics in the mechanical and engineering industries, 1983.

(5) According to SITC Rev. 2, Groups 711, 714, 716, 771, 772, 773. Source: United Nations, Yearbook of Industrial Statistics, 1980 edition (1980 figures).

(e) Estimated.

C_1 to C_5 according to section 2.4.2.

2.4.2 A graphical representation of selected indicators

Three graphs were prepared from the above data, with population as common reference variable. In fact, population is the simplest and the least disputable criterion for a first classification of the countries and three classes of countries are used:

Countries with small population: less than 5 million inhabitants
Countries with medium-sized population: 5-20 million inhabitants
Countries with large population: more than 20 million inhabitants

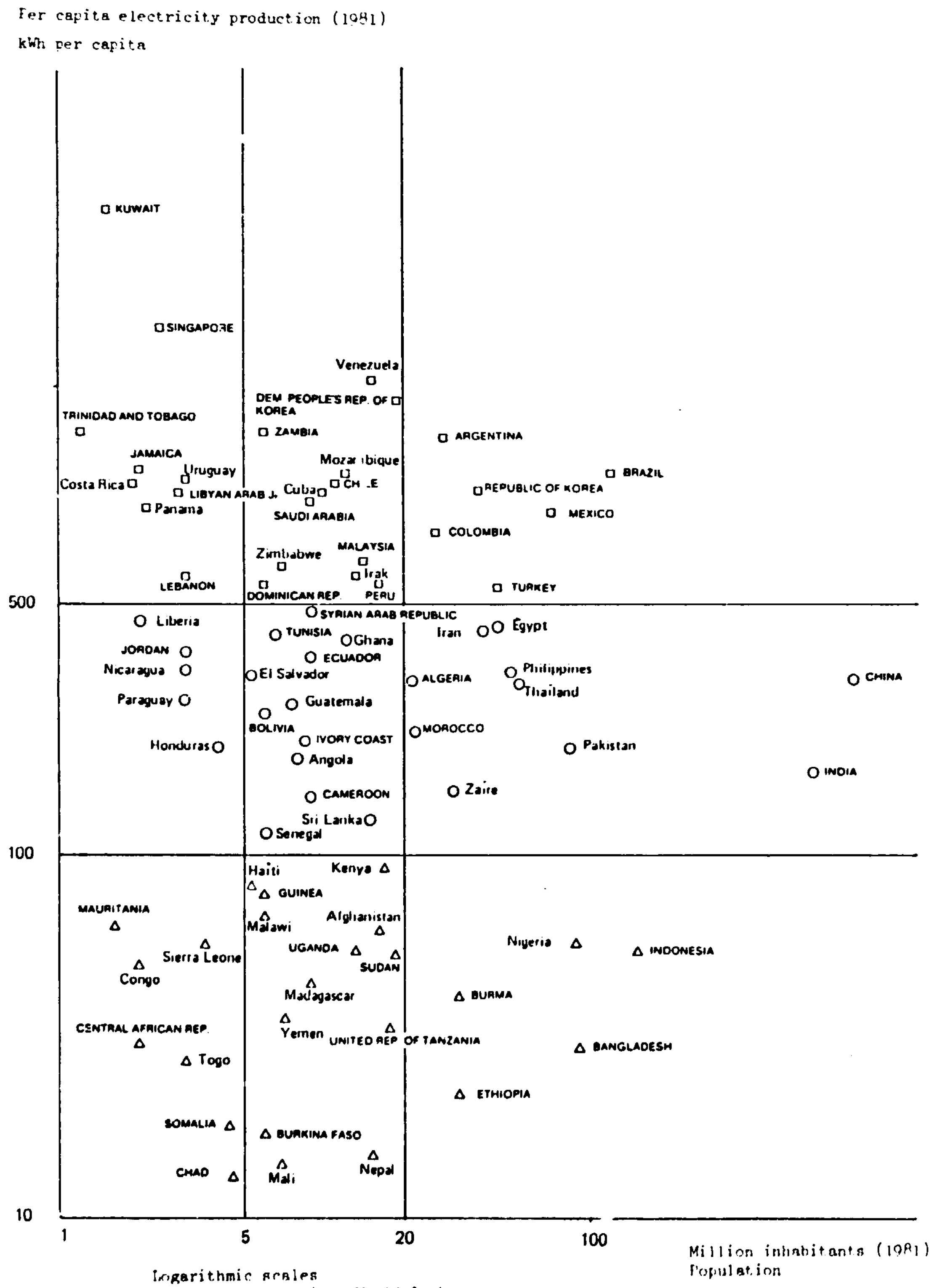
Figure 3 classifies the countries according to their per capita electricity production, three classes of countries being distinguished:

Countries of low electrification level: less than 100 kWh/year per capita
Countries of medium electrification level: 100-500 kWh/year per capita
Countries of high electrification level: more than 500 kWh/year per capita

The class of countries at a low electrification level includes countries of every size. In this group one finds the majority of the least developed countries and two major petroleum producing countries - Indonesia and Nigeria. The class of countries with a medium electrification level also contains countries of every size, but with a predominance of medium-sized and large countries, particularly the People's Republic of China and India. Finally, the class of countries with a high electrification level consists of a very diverse groups of countries: (a) Small countries such as Costa Rica, Panama and Singapore; (b) Petroleum producing countries (Iraq, Kuwait, Libya, Saudi Arabia and Venezuela); (c) Countries with a medium and in some cases a low income level, whose electric power production can be explained by specific domestic factors: Mozambique - major hydroelectric dam and large-scale exports; Chile, Jamaica, Zambia - mining countries, etc.; (d) The most advanced developing countries or those referred to as the newly industrializing countries (NICs): Argentina, Brazil, Mexico and Republic of Korea.

Figure 3

Classification of the developing countries by per capita electricity production and population



Logarithmic scales
Sources: Population, World Bank
Electricity, Business International

Figure 4 classifies the countries according to their imports of electric power equipment in 1981. These imports, even calculated for a single year, give a significant indication of the domestic market, except in the case of the ten or so countries that produce electric power equipment. The following classes may be distinguished:

Countries with a low level of imports: less than $US 50 million
Countries with a medium level of imports: $US 50 - 300 million
Countries with a high level of imports: more than $US 300 million

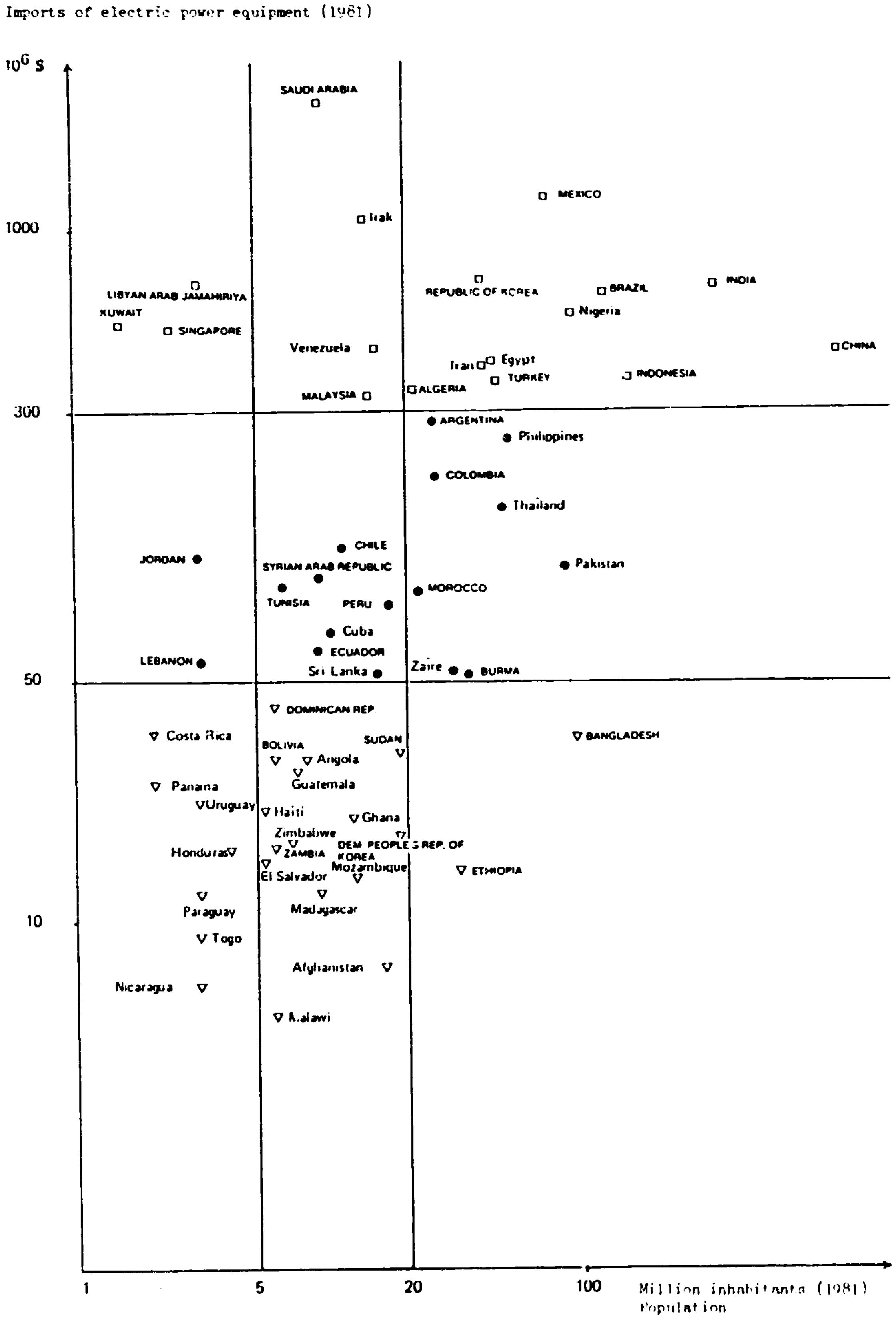
The countries with a low level of imports form a diverse group: small countries that have already achieved a certain level of electrification (Costa Rica, Panama), countries with low and very low income (Ethiopia, Bangladesh, Madagascar, Sudan), and countries such as Angola, Mozambique, Nicaragua, Zimbabwe. On the other hand, the class of countries with a medium level of imports is more homogeneous. It includes medium-sized and large countries and countries with a middle level of income. Finally, the class of countries with a high level of imports includes two quite distinct categories: the petroleum producing countries, whose domestic financing capacity allows them to implement electrification projects (Algeria, Indonesia, Kuwait, Libya, Malaysia, Nigeria, Saudi Arabia, etc.) and the newly industrializing countries, which, while they have considerable production capacity for capital goods, are still very large-scale importers.

Figure 5 classifies the countries according to their production of capital goods measured by value added in the engineering, electrical and transport equipment industries. A distinction is made between five classes by analogy with the classification of capital goods according to their degree of complexity.[8/] These classes (C_1 to C_5) are:

8/ Six levels of complexity have been defined in earlier work by UNIDO. In that analysis the production of equipment of complexity level 5 has already been attained by the newly industrializing countries, whereas the production of capital goods of complexity 6 is the prerogative of the most fully industrialized countries. See UNIDO, First Global Study on the Capital Goods Industry: Strategies for Development, ID/WG.342/3, 3 July 1981.

Figure -

Classification of developing countries by imports of electric power equipment and population

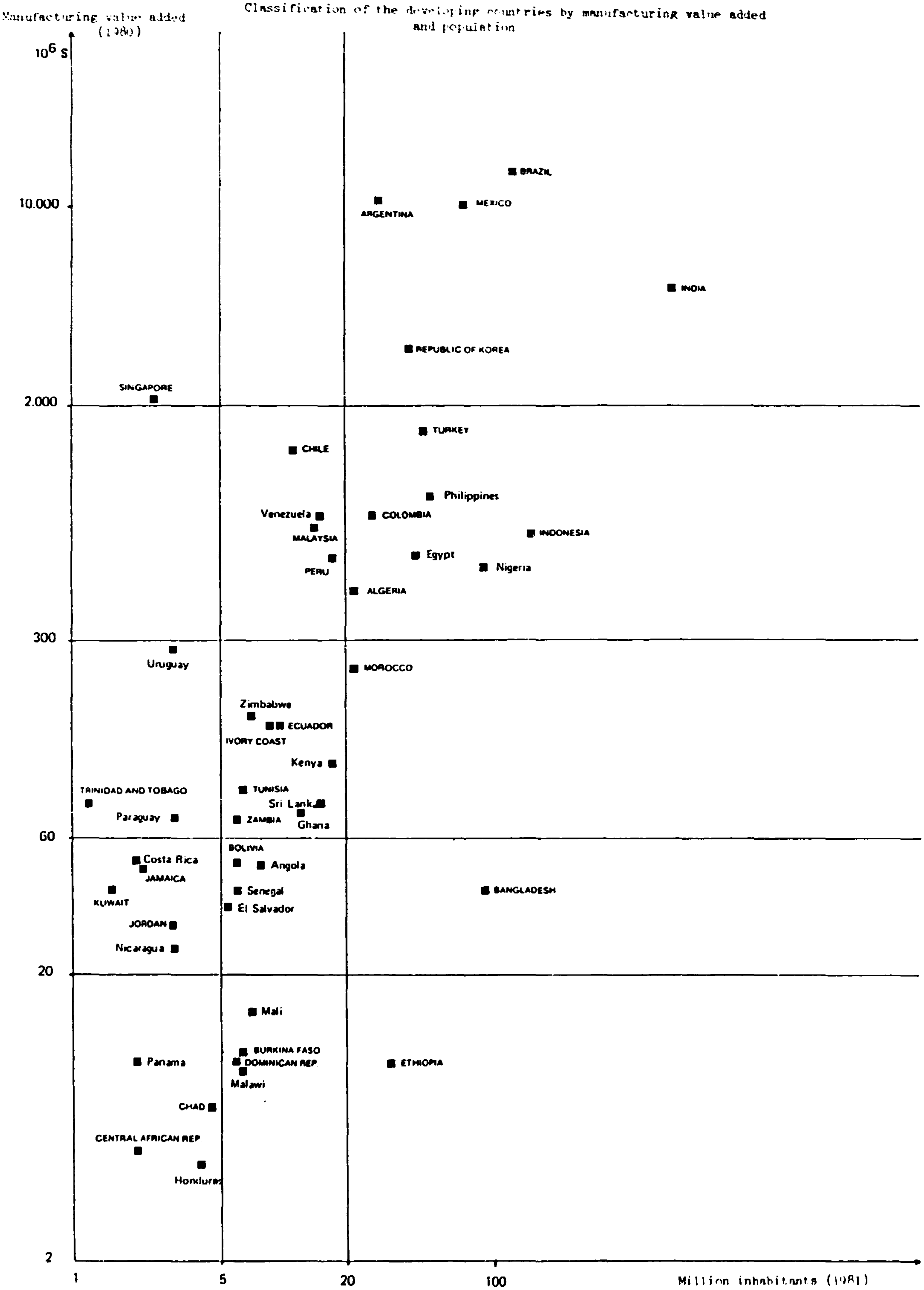


Logarithmic scales

Sources: Population: World Bank
Imports: United Nations, ECE

Figure 5

Classification of the developing countries by manufacturing value added and population



Logarithmic scales
Sources: Population, World Bank
Manufacturing value added: UNIDO

C_1: Production less than $US 20 million

C_2: Production between $US 20 and $US 60 million

C_3: Production between $US 60 and $US 300 million

C_4: Production between $US 300 and $US 2,000 million

C_5: Production more than $US 2,000 million.

It is assumed that for any given country there is a correlation between the absolute value of production of capital goods and the level of complexity of the capital goods manufactured.

2.4.3 Elaboration of the typology

As was described above, the typology attempts a grouping of developing countries according to their potential production capacity of electric power equipment and their market potential. It is recalled that the criterion for determining the production potential is:

- Value added in the engineering, electrical and transport equipment industry;

The criteria used for describing the market potential are:

- Population
- Per capita production of electricity
- Imports of electric power equipment.

Breakdown of selected criteria

The production potential criterion is broken into five classes as described in section 2.4.2 above. The classes are henceforth designated as follows:

C_1 and C_2: Low capacity for starting or developing the manufacture of electric power equipment

C_3: Medium level development capacity

C_4: High development capacity

C_5: Very high development capacity lacking merely a few elements of a complete electric power equipment industry.

It is recalled that the population criterion is broken into three classes as follows:

Class 1: Countries with less than 5 million inhabitants
Class 2: Countries with between 5 and 20 million inhabitants
Class 3: Countries with more than 20 million.

The criterion concerning per capita production of electricity is broken into three classes:

Class 1: Countries with less than 100 kWh/year
Class 2: Countries with between 100 and 500 kWh/year
Class 3: Countries with more than 500 kWh/year.

The criterion of imports of electric power equipment is broken down as follows:

Class 1: Countries with less than $US 50 million in 1981
Class 2: Countries with between $US 50 and $US 300 million
Class 3: Countries with more than $US 300 million.

Determination of market potential

The market potential is determined through the construction of an index number for each country, with a value between 3 and 9, by the following method:

A value of one is attributed to a country whenever it belongs to the lowest class according to the criteria for population, per capita production of electricity or imports of electric power equipment. Whenever countries belong to the second class, a value of 2 is attributed and when they belong to the highest class a value of 3. These values are added into index numbers which are presented in table 3.a.

The following designations have been adopted to countries in the various index groups:

Indices 3 and 4: Countries with very low market potential
Indices 4 and 5: Countries with low market potential
Indices 5 and 6: Countries with medium market potential
Indices 7 and 8: Countries with high market potential
Indices 8 and 9: Countries with very high market potential

Table 3.b shows the actual classification of the countries under analysis according to the above criteria. Furthermore the criterion for potential production capacity based on MVA in mechanical and electrical engineering industries has been included in table 3.b. Table 3.b can therefore serve as the basis for the final construction of the typology.

Final grouping of countries according to market potential and production capacity potential

Combining the index numbers describing the market potential and the classification categories of the production capacity with the classification categories for population will result in the identification of 9 country groups as shown in table 4.a. Table 4.b is an expansion of table 4.a, using also the criterion of potential production capacity. The identified 9 groups can immediately be reduced to 7 since:

(a) Singapore, a small country, could be classified in group 7, consisting of semi-industrialized countries

(b) Four medium-sized countries, with large markets and high capacity (Chile, Malaysia, Peru, Venezuela) have the same potential as large countries and accordingly could be classified in group 6 (countries with large market and high capacity).

Table 3.a. Calculation of indices for market potential

Imports of electric power equipment in million $US		Population in million: Less than 5 (1)			Between 5 and 20 (2)			Above 20 (3)		
		Electricity production in kWh/year								
		100 (1)	100-500 (2)	500 (3)	100 (1)	100-500 (2)	500 (3)	100 (1)	100-500 (2)	500 (3)
Less than 50	1	3	4	5	4	5	6	5	6	7
Between 50-300	2	4	5	6	5	6	7	6	7	8
Above 300	3	5	6	7	6	7	8	7	8	9

Table 3.b. Classification of the countries by four criteria

Imports of electric power equipment (million $US)	Potential production capacity*	Population in million: Less than 5			Between 5 and 20			Above 20		
		Electricity production in kWh/year								
		100	100-500	500	100	100-500	500	100	100-500	500
Less than 50	C1	Central African Republic Chad Congo Mauritania Sierra Leone Somalia Togo	Honduras Liberia	Panama	Afghanistan Burkina Faso Guinea Haiti Madagascar Malawi Mali Nepal Yemen Arab Republic		Dominican	Ethiopia Republic		
	C2		Nicaragua	Costa Rica Jamaica	Sudan Tanzania Uganda	Angola Bolivia Cameroon El Salvador Guatemala Senegal	Mozambique	Bangladesh		
	C3		Paraguay	Uruguay	Kenya	Ghana Ivory Coast	Zambia Zimbabwe Dem. Rep. of Korea			
Between 50 and 300	C1								Zaire	
	C2		Jordan	Lebanon				Burma		
	C3			Trinidad & Tobago		Tunisia Ecuador Sri Lanka Syria	Cuba		Morocco	
	C4						Chile Peru		Pakistan Philippines Thailand	Colombia
	C5									Argentina
Above 300	C2			Kuwait Libya						
	C3						Iraq Saudi Arabia			
	C4						Malaysia Venezuela	Indonesia Nigeria	Algeria Egypt Iran	Turkey
	C5			Singapore					China India	Brazil Rep. of Korea Mexico

* Based on MVA in mechanical and electrical engineering industries.

Table 4.a. Groups of developing countries

Population in million		
Less than 5	Between 5 and 20	Above 20
Countries with Very small market (indices 3 and 4) Low capacity (C1, C2)		
Countries with Medium-sized market (indices 5 and 6) Low to medium capacity (C2, C3)	Countries with Small market (indices 4 and 5) Low capacity (C1,C2)	
	Countries with Medium market (indices 5 and 6) Medium capacity (C3)	Countries with Medium market (indices 5 and 6) Low capacity (C1,C2)
	Countries with Large market (indices 7 and 8) High capacity (C4)	Countries with Large market (indices 7 and 8) High capacity (C4)
Countries with Large market (index 7) High capacity (C5)		Countries with Very large market (indices 8 and 9) Very high capacity (C5)

Table 4.b. Typology of developing countries

Population in million: Less than 5	Between 5 and 20	Above 20
Group 1: Very small market/ low capacity 1. Central African Republic 2. Chad 3. Congo 4. Honduras 5. Liberia 6. Mauritania 7. Nicaragua 8. Pataguay 9. Sierra Leone 10. Somalia 11. Togo		
Group 2: Medium sized market/ low to medium capacity 1. Cost Rica 2. Jamaica 3. Jordan 4. Kuwait 5. Lebanon 6. Libya 7. Panama 8. Trinidad and Tobago 9. Uruguay	**Group 3**: Small market/low capacity 1. Afghanistan 2. Angola 3. Bolivia 4. Burkina Faso 5. Cameroon 6. Dominican Republic 7. El Salvador 8. Guatemala 9. Guinea 10. Haiti 11. Madagascar 12. Malawi 13. Mali 14. Mozambique 15. Nepal 16. Senegal 17. Sudan 18. Tanzania 19. Uganda 20. Yemen Arab Republic	
	Group 4: Medium-sized market/medium capacity 1. Cuba 2. Ecuador 3. Ghana 4. Iraq 5. Ivory Coast 6. Kenya 7. Korea, Dem. Rep. 8. Tunisia 9. Saudi Arabia 10. Sri Lanka 11. Syria 12. Zambia 13. Zimbabwe	**Group 5**: Medium-sized market/ low capacity 1. Bangladesh 2. Burma 3. Ethiopia 4. Zaire
	Group 6: Large market/large capacity 1. Chile 2. Malaysia 3. Peru 4. Venezuela	**Group 6**: Large market/large capacity 1. Algeria 2. Colombia 3. Egypt 4. Indonesia 5. Iran 6. Morocco 7. Nigeria 8. Pakistan 9. Philippines 10. Thailand 11. Turkey
Group 7: Large market/large capacity 1. Singapore		**Group 7**: Very large market/ very large capacity 1. Argentina 2. Brazil 3. China 4. India 5. Korea, Rep. 6. Mexico

Description of the final grouping

A. Countries with a small population (less than 5 million inhabitants)): 20 countries

Group 1. Very small market, low capacity; 11 countries: Central African Republic, Chad, Congo, Honduras, Liberia, Mauritania, Nicaragua, Paraguay, Sierra Leone, Somalia, Togo. (In this group one can also include Benin, Bhutan, Burundi, Democratic Yemen, Lesotho, Lao People's Democratic Republic, Mongolia, Niger and Rwanda).

Group 2. Medium-sized market, low to medium capacity; 9 countries: Costa Rica, Jamaica, Jordan, Kuwait, Lebanon, Libya, Panama, Trinidad and Tobago, Uruguay. (The United Arab Emirates can be classified in this group. Note: Singapore would belong to this group but has been classified - as indicated above - as a semi-industrialized country in group 7).

B. Countries with a medium-sized population (between 5 and 20 million inhabitants): 33 countries.

Group 3. Small market, low capacity; 20 countries: Afghanistan, Angola, Bolivia, Burkina Faso, Cameroon, Dominican Republic, El Salvador, Guatemala, Guinea, Haiti, Madagascar, Malawi, Mali, Mozambique, Nepal, Senegal, Sudan, Tanzania, Uganda, Yemen Arab Republic. (Democratic Kampuchea could be included in this group).

Group 4. Medium-sized market, medium capacity; 13 countries: Cuba, Democratic People's Republic of Korea, Ecuador, Ghana, Iraq, Ivory Coast, Kenya, Saudi Arabia, Sri Lanka, Syria, Tunisia, Zambia, Zimbabwe. (Note: 4 countries with large market and high capacity - Chile, Malaysia, Peru, Venezuela have been classified in group 6: countries with large populations that already have a developed capital goods sector).

C. Countries with a large population (more than 20 million inhabitants 26 countries.

Group 5. Medium-sized market, low capacity; 4 countries: Bangladesh, Burma, Ethiopia, Zaire. (Viet Nam could be included in this group.)

Group 6. Large market, high capacity; 15 countries: Algeria, Colombia, Egypt, Indonesia, Iran, Morocco, Nigeria, Pakistan, Philippines, Thailand, Turkey as well as Chile, Malaysia, Peru and Venezuela as indicated above.

Group 7. Semi-industrialized countries; 7 countries: Argentina, Brazil, China, India, Republic of Korea, Mexico and Singapore.

It is recalled that the country case studies that have been carried out by UNIDO cover the following groups:

Two studies concerning Group 3:	Bolivia, Cameroon, Tanzania
Five studies concerning Group 6:	Indonesia, Pakistan, Algeria, Egypt, Colombia
Three studies concerning Group 7:	Republic of Korea, Mexico, India.

The selection of country case studies was made following an earlier, tentative, version of this typology.

3. ELEMENTS OF STRATEGY

3.1 General remarks on strategies

For each group of countries it was tried to specify the possible development strategies for the electric power equipment sector, on the basis of the various country case studies prepared by UNIDO[9/] and on the more specific papers prepared by the Institut de Recherche Economique et de Planification du Développement.[10/] Six strategies will be developed. The four countries in group five (Bangladesh, Burma, Ethiopia, Zaire) have, however, too specific characteristics to allow the proposal of a homogenous strategy. Possible strategies for this group could be similar to those of the group of medium-sized population, small market and low technical capacity (group 3) and to those of the group of countries with medium-sized population, medium-sized market and medium technical capacity (group 4). What should be noted above all for this group of countries is the size of their potential market and their weakness in mastering the capital goods sector.

Before giving details of each strategy, it is necessary to emphasize a number of points and trends common to all the groups of countries.

All the activities and products linked to the generation, transmission and distribution of electric power must be taken into consideration. The purpose of this approach is not to limit targets merely to the production of capital goods and consequently not to exclude a large number of countries from

. . . .

9/ Algeria, Bolivia, Cameroon, Colombia, Egypt, India, Indonesia, Mexico, Pakistan, Republic of Korea, United Republic of Tanzania.

10/ - A. Gaulé - Les biens de capital pour la production et la distribution d'énergie électrique, (capital goods for the generation and distribution of electric power) November 1979.

- A. Gaulé, R. Chaponnière, R. Tiberghien, P. Vernet - La coopération industrielle avec les pay en développement à partir de l'électrification rurale. (Industrial co-operation with the developing countries on the basis of rural electrification)

- R. Tiberghien - Problèmes technologiques dans le secteur des biens d'équipement - la Tunisie (Technological problems in the capital goods sectory - Tunisia) - UNCTAD/TT/53, 1982.

the scope of discussion. Tables 5, 6 and 7 show clearly that equipment in the strict sense represents on the average only 50 per cent of investments (for a medium voltage distribution line, the share of equipment is even lower). It is necessary to take into account:

(a) Repair and maintenance, the learning effects of which are very important for countries starting the process of industrialization;

(b) Assembly, which represents up to 50 per cent of the cost of the investment;

(c) Civil engineering activities which represent approximately 25 per cent of the cost of the investment;

(d) So-called software activities: the services of consultants for general planning studies, feasibility studies, engineering services for the preparation of project studies and R&D activities.

Among the economic agents, the Government plays a considerable role. It is not without reason that the role of the Government is emphasized. In most countries, whether developed or developing, the Government has the final control of the entire energy system and in particular of the generation, transmission and distribution of electric power. Accordingly, the Government and its specialized bodies, will tend to get heavily involved in:

- Drawing up medium and long-term energy development plans;
- Making investment studies;
- Selection of partners for co-operation;
- Supervision of the erection of the installations;
- Organization of the maintenance of the installations;
- Promotion of specific training programmes;
- Promotion of national consultancy and engineering companies;
- Promotion of a national industry for electric power equipment;
- Developing a policy for the purchase of technology.

Table 5. Thermal power station - breakdown of costs
(per cent of total cost)

Type of Activity	Breakdown according to type of activity	Of which: Less complex activities	Moderately complex activities	Complex activities	Very complex activities
Engineering	10				
Civil engineering	25	20	5	-	-
Equipment	50				
including:					
Structures, Boilermaking	17	3	1	13	-
Foundry, Machining	17	-	0.5	6.5	10
Switchgear and control equipment	16	-	0.5	3	12.5
Assembly	15	10	3.5	1.5	-
Total	100	33	10.5	24	22.5

Table 6. Diesel power and mini-hydro stations - breakdown of costs

Activity		Per cent of total cost	Activity	Per cent of total cost
Diesel power station			Mini-hydro station	
Design, engineering		10	Design	10
Civil engineering		20	Civil engineering	50
Assembly		15	Hydraulic equipment	20
Equipment, including		55	Electrical equipment	20
Engine	30			
Alternator	10			
Electrical equipment and instrumentation	10			
Fuel storage	5			
Total		100		100

Table 7. Very high voltage, high voltage and medium voltage transmission networks - breakdown of costs

Activity		Per cent of total cost
1. Overall network		
Civil engineering		30
Equipment (circuit-breakers, disconnecting switches, transformers)		70
	Total	100
2. Very high voltage and high voltage lines		
Appliances		30
Cables, towers, accessories		30
Assembly		40
	Total	100
3. Medium voltage lines		
Appliances		10
Cables, poles, accessories		40
Assembly		50
	Total	100

A genuine start-up of the production of electric power equipment necessitates technological unpackaging and consequently the development of national engineering capability. All the country studies insist on this point. Certain countries like Brazil, Egypt, the Republic of Korea and Indonesia have established legislation for the purpose, firstly to promote national engineering companies and secondly to ensure that the turnkey approach is not considered as the only means of making investments. In this context, it should be pointed out that also countries of the smallest size that as yet manufacture equipment (for example, Tunisia) are setting up a strategy for technology unpackaging so that they can entrust to the national industry the manufacture of sub-assemblies of low to medium complexity (metal structures, boiler-making products).

In the framework of national strategies emphasis must be given to the development of an industry that manufactures equipment for the domestic market. This import substitution or self-reliance strategy is the only possible approach for most of the countries. In this field it seems difficult to base a policy on the export of part of the production because the products must meet quality standards and exports must be accompanied by proposals for financing. The majority of the developing countries can only meet these two essential requirements with difficulty. This point of view does not mean, however, that it is not necessary to make significant efforts to make the production of equipment possible at the regional level. Similarly, experience shows that the new industrializing developing countries have begun to export some items of electric power equipment, such as motors, distribution transformers and low voltage gear.

For all countries the question of the linkage between the electric power equipment sector and the capital goods sector as a whole is fundamental. These linkages can be regarded from the following viewpoints:

(a) Upstream linkages: iron and steel and metallurgy. In the countries that are at the beginning of the industrialization process, this linkage does not exist. The development of the upstream sector can even be regarded as not indispensable because the relevant investments are very considerable and the establishment of an upstream sector does not significantly increase the level of national content in electric power equipment. On the other hand, for countries whose industry has already reached a substantial level of development, a better linkage between the upstream sector and the electric power equipment sector is necessary.

(b) Linkage to basic activities of the capital goods industry and to subcontracting. This relates to linkages to foundries, forging, mechanical engineering and heat treatment. These activities form the basis of a capital goods industry and the production of electric power equipment should give an impetus to the development of such infrastructure. It seems clear from the case studies on the most advanced countries that the establishment of these basic activities is a necessary intermediate stage to increase the national content significantly. But this requires very substantial investments.

The linkage with the sub-contracting sector is based on a different industrial organization. It is necessary to create linkages between the major enterprises and the small and medium-scale enterprises in order to derive the maximum benefit from economies of organization and specialization. This industrial strategy is to some extent opposed to that based on the construction of vertically integrated large complexes.

(c) The last form of linkages would be producing other equipment by setting up multipurpose machine shops, multipurpose assembly shops, etc. This strategy can reasonably be adopted by all countries beginning to develop the capital goods sector and in these countries agriculture and energy constitute two national priorities. One can then envisage joint production of agricultural equipment, equipment for renewable energy, simple equipment for the distribution of electric power, such as poles, distribution boxes and line disconnecting switches.

Finally, with regard to international co-operation, two points should be emphasized: the role played by the transnational enterprises and the question of financing investments.

It should be recalled that some twenty transnational corporations originating in the industrialized countries basically control the sector. These firms have developed a strategy for the internationalization of production in the form of majority holdings in subsidiaries, joint ventures, sales of licences. Moreover, they control the market of the developing countries. The importance of financing and the use of standards are other factors which contribute to an oligopolistic situation in the field of heavy electric power equipment. The objectives of developing countries should be to strengthen their national capability of consultation and studies and the establishment of technological legislation. This would strengthen their bargaining position. In this general framework the strategies of the developing countries to arrive at a stage of autonomous development and the strategies of the corporations to penetrate or retain markets are not impossible to reconcile. Each of the partners may hope to find areas for negotiation, in particular in the field of the transfer of technology. In a world suffering from crisis and market recession, certain developing countries may play the purchaser's trump card to acquire technologies and the foreign partner knows that in order to preserve market shares he has no other choice but to transfer his technology, even as a minority partner. Beyond the transfer of technology, the implementation of an industrial co-operation policy must be possible.

The second point concerns the financing of electrification programmes. For countries with low and medium income, for example Bolivia and Tanzania the future as far as the implementation of electrification programmes is concerned is quite grim. The transnational corporations have registered a slump in invitations to international tender since the end of 1983, which will lead in the coming two years to a substantial drop in orders. An international consultation on the development of the electric power equipment industry in developing countries should try to touch on this question.

3.2 Plan of presentation of strategies

For each group of countries the following presentation has been adopted:

(a) General characteristics of each group of countries: level of development, significant development characteristics, financing capacity, characteristics of the capital goods industry, etc.

(b) Energy resources and policies: an attempt will be made to indicate natural resources and potential as well as the major energy strategy options.

(c) Strategies. Three points will be developed.

(i) Constraints.

(ii) The targets to be aimed at in the following fields:

- Consultancy activities
- Engineering activities
- R & D
- Repair and maintenance
- Civil engineering

- Assembly and supervision
- Production of equipment:
  - Low and medium voltage cables, switchboxes, poles, cables
  - Medium, high and very high voltage distribution equipment
  - Electric power generation equipment.

(iii) The implementation of these strategies, emphasizing particularly:

- The role of different actors, particularly the Government
- Linkages with the capital goods sector as a whole
- Technological policy, particularly specialized training, the development of engineering activities, etc.
- Needs with regard to co-operation.

3.2.1 Group 1. Very small market; low capacity

Central African Republic, Chad, Congo, Honduras, Liberia, Mauritania, Nicaragua, Paraguay, Sierra Leone, Somalia, Togo.

(a) General characteristics

The 12 countries in this group, with less than 5 million inhabitants[11/] are characterized mainly by:

- Their restricted domestic market; and
- Their low technical level.

In addition to these main elements revealed by the typology there are some supplementary data that will characterize these countries with regard to their strategies for electrification and the mastery of the first stages of

11/ It would be possible to include in this group 10-15 other countries, namely, those for which statistics were not very reliable, as well as those with populations of less than one million (Belize, Guinea-Bissau, Suriname, Swaziland).

technology linked to electrification. Most of them are in the group of least developed countries. The average growth of per capita GDP was low (1 per cent annually) in the period 1970-1981. The manufacturing sector began to develop around the 1960s and later development had to be based mainly on agriculture, with the corollary that it was necessary to implement a genuine rural development policy.

The electrification rate is low (less than 100 kWh/year per capita on the average) and only 5-10 per cent of households have electricity. Electrification is possible only by means of bilateral or multilateral financing, because the countries' own financing capacity is very low.

Finally, the engineering industry is at a very low level of development and consists of a few repair and maintenance workshops and workshops for the production of agricultural implements and small agricultural machinery. The handicraft sector plays an important role there.

(b) Energy resources and policies

Except for the Congo, these countries do not at present have any hydrocarbon resources and, generally speaking, their hydroelectric potential is limited. This means that progress in electrification will be made by imported resources, pending notable progress in the field of new and/or decentralized forms of energy. This constraint may limit the rate of electrification, with all the consequences on potential markets.

(c) Strategies

(i) Constraints. The constraints have already been referred to, but their effect is very great. In particular, the constraints are:

- The lack of resources to finance the capital goods industry by electrification programmes.

- The very small market: absolute consumption for this group of countries is in the order of 100-200 GWh/year, i.e., 10 times less than the group of medium-sized countries (Bolivia, Tanzania).[12/]

- Very great weakness in the field of mastering technology.

(ii) Activities and products. National efforts should be devoted to the following fields:

- The operation and maintenance of power stations. All the above-mentioned country case studies insist on this point, because maintenance is the starting point for training a generation of skilled manpower. Moreover, judicious management of spare parts can lead to substantial savings in foreign exchange.

- The development of domestic consultancy firms for the definition of energy strategies, long-term plans, feasibility studies and the monitoring of projects. The case study on Bolivia shows that these activities began around the 1960s and that 25 years later the national participation in this work is in the order of 50 per cent and that the cost is 30-40 per cent lower than international prices.

- In the field of capital goods proper, very little can be envisaged in the coming ten years. However, it would be desirable to develop the ability to participate in civil engineering and in assembling work as well as in the field of wiring low and medium voltage distribution switchboards.

12/ The two countries referred to possess an industry for the manufacture of distribution transformers operating under difficult profitability conditions. With a growth rate of consumption of 8 per cent per annum in the countries of group 1, it would take 30 years before consumption increased by a factor of 10.

(iii) Implementation. The experience of the other countries shows that special efforts must be made in the field of training:

Training for maintenance may take several forms: (a) Courses in the factory of the supplier of equipment or in equivalent power stations; (b) specialized courses in foreign countries; (c) participation in the assembly and start-up of power stations; (d) finally, the systematic organization of courses in the country itself.

Training for planning studies and mastering the complex of consulting activities may be accelerated by technical assistance agreements. All the country case studies referred to specialized technical assistance from very diverse countries such as Canada (through ACDI), France (EDF International), the Federal Republic of Germany and the USSR.

The state has an important role to play in all these fields:

- To promote consultancy firms;
- To promote maintenance training courses;
- To promote and negotiate technical assistance agreements;
- To stipulate that nationals must participate in assembly and civil engineering work.

3.2.2 Group 2. Medium-sized market, low to medium capacity

Costa Rica, Jamaica, Jordan, Kuwait, Lebanon, Libyan Arab Jamahiriya, Panama, Trinidad and Tobago and Uruguay.

(a) General characteristics

This group of nine countries with populations of less than 5 million is different from the preceding group in two respects:

- The market size: annual consumption is in the order of 2,000 - 4,000 GWh. Most of the countries have a high per capita electrification rate above 500 kWh/year.

- The degree of mastering technology is higher.

Two petroleum producing countries belong to this group (Kuwait and the Libyan Arab Jamahiriya)[13/] and are very large-scale importers of electric power equipment financed by own resources.

These countries have middle-range per capita income (Costa Rica $US 1,420, Jordan $US 1,620, Panama $US 1,910, Paraguay $US 1,630) with a high urbanization rate and a manufacturing sector that accounts for more than 10 per cent of GDP.

(b) Energy resources and policies

Most of the countries are producers of hydrocarbons or have access to them on preferential terms (Costa Rica, agreement with Mexico and Venezuela; Jordan, agreement with Arab producers). Electrification is already very advanced (more than 500 KWh/year per capita) and there is no major obstacle towards the continuation of electrification.

The energy policy is therefore linked to demand from economic sectors (industry, agriculture, services), which already constitute a market and which are expected to expand in the future.

(c) Strategies

(i) Constraints. A market thus exists, which, however, will remain moderate in size. It should permit the production of simple equipment such as electric motors, distribution transformers and certain sub-assemblies for power stations.

13/ Petroleum producing countries with less than one million inhabitants could also be included in this group: Bahrein, Oman, Qatar, etc.

(ii) Activities and products. Study and consultancy activities should develop considerably in order to make it possible to master most of the long-term and feasibility study activities. It is conceivable that, with the aid of foreign technical assistance, these countries can carry out detail engineering studies locally for transmission lines and stations and for parts of the power stations.

In view of the technological level achieved by these countries, it seems possible to carry out locally most of the civil engineering and assembly work, which represents about 40 per cent of the price of a power station, 30 per cent of the price of a very high and high voltage station and 40-50 per cent of the price of very high, high and medium voltage lines.14/

As far as equipment is concerned, it should be possible for certain countries to commence the manufacture of low and medium voltage wires and cables and of electric motors and distribution transformers.

(iii) Implementation. See the measures advocated in section 3.2.1, since the situations are almost identical.

3.2.3 Group 3. Small market, low capacity

Afghanistan, Angola, Bolivia, Burkina Faso, Cameroon, Dominican Republic, El Salvador, Guatemala, Guinea, Haiti, Madagascar, Malawi, Mali, Mozambique, Nepal, Senegal, Sudan, Tanzania, Uganda, Yemen Arab Republic.

14/ Cf. tables 5, 6 and 7.

(a) General characteristics

This is the largest group of countries (20 countries), the chief characteristics of which are that their technical capacity is still limited, and that the market is still not large. However, if these countries implement appropriate strategies, it is conceivable that in the coming ten years or so some of them will either commence engineering activities or start manufacturing electric power equipment. This indicates the importance that should be attached to this group.

Nevertheless, the group has quite heterogeneous characteristics:

- As regards the rate of electrification, 12 countries have electric power production below 100 kWh/year per capita, and 6 have values between 100 and 500 kWh/year.

- As regards income, some of the countries are still classified as least developed countries (Burkina Faso, Nepal, Tanzania), while others have a higher per capita income (Bolivia, Cameroon).

- As regards industrialization, all these countries have begun their industrialization process, in particular using their own natural resources, and for some of them the manufacturing industry already accounts for between 5 and 10 per cent of the GDP.

As far as the mastering of technology is concerned, the situation can be ascertained in the light of a few cases: (a) Nepal (table 8); (b) Bolivia and Tanzania (table 9).

It will be found that the capital goods industry is in an embryonic condition. The first production plants for electric power equipment date from the 1960s in Bolivia. They are much more recent in Tanzania. In general the enterprises do not use their production capacity in full, mainly because of the lack of components, sub-assemblies and raw materials, which these two countries have difficulty in importing because of the shortage of foreign exchange. As far as Nepal is concerned, development is oriented towards mini hydro plants.

Table 8. Nepal: The electric power equipment
Major categories of machinery and equipment, producers, users and their prospects

		Major machinery and equipment produced	Main producers M = modern T = traditional	Main users	Future prospects
Direct (Pure capital goods)	Mechanical	a) agricultural machinery (tractor attachments, rice huller, flour mills, oilpressers, threshers)	M	farmers	bright (modernization of agriculture)
		b) spinning and weaving machinery (power looms)	M	cottage industries	reasonably bright (There is sufficient demand, but the problem is the increasing imports of machine-woven cloths from India)
		c) carpentry machinery (circular saws, electric planers, wood lathes)	M	carpenters, construction industries.	bright (Hotel construction boom)
	Non-mechanical	a) agricultural tools (hand tools)	M (ATF, etc.) T (blacksmiths)	farmers	not promising
		b) spinning and weaving tools (pedal looms)	T (carpenters)	farmers	not promising
		c) carpentry and artisan tools (augers, chisels, planers, saws, adzes, brick choppers, plumb lines)	M T (blacksmiths)	carpenters masons and farmers	bright
Indirect	Mechanical (quasi-capital goods)	a) energy generating equipments (water turbines, water wheels, hydrolic rams, pumps, gobar gas tanks, etc.)	M	local governments (development projects)	bright (Government projects)
		b) electrical equipments (air coolers, electric cookers)	M	households	bright
		c) transportation equipments (wheel barrows)	M	factories	
	Non-mechanical (Pseudo-capital goods)	a) infrastructural equipments (suspension bridges, water gates)	M	government	bright (government projects)
		b) construction materials (roof trusses, grilles, window frames, iron gates)	M petty welding	construction industries & households	bright (hotel construction boom)
		c) steel furniture (steel almirah, steel desks, etc.)	M (furniture work)	government and private offices	bright

Table 9. Bolivia and Tanzania: Data on the electric power equipment industry

Bolivia			Tanzania	
Bolivia	Employment: 180 persons		Tanzania	Employment: 252 persons
<u>Distribution transformers (2 enterprises)</u>			<u>Distribution transformers and switchboards</u>	
1 plant dating from 1968 production 40 units	25 persons	National technology	1 plant dating from 1981 Capacity 400 units, production 214 units in 1983, Norwegian technology	
1 plant dating from 1976 production 50 units	25 persons	US technology	Later production of switchboards (11 kV) and insulators	
<u>Cables (2 enterprises)</u>			<u>Cables</u>	
1 plant dating from 1964	Copper and aluminium conductors PVC insulated		1 plant dating from 1978 Copper conductors, PVC insulated	
1 plant dating from 1973			Japanese technology - Production 1983: 400 tons	
<u>Poles (3 enterprises)</u>			<u>Poles</u>	
1 plant dating from 1969 concrete poles - FRG technology for 69 kV lines			1 plant for wooden poles Capacity 20,000 units/year Australian technology	
1 plant dating from 1977 for rural electrification projects (concrete poles)				
1 plant for wooden poles using eucalyptus US technology				

<u>Source</u>: UNIDO country case studies.

(b) Energy resources and policies

Most of the countries have limited resources, except Angola (petroleum), Bolivia (gas) and Mozambique and Nepal (hydroelectric potential). Electrification is still at a low level of development.

The main priority in the energy sector should be electrification linked to rural development, and development of an equipment industry supported by the local market. However, the information in the case studies on Bolivia and Tanzania (table 10) tends to show that these two countries are severely hit by the international crisis. Consumption of electricity rose by only 6 per cent between 1972 and 1982, while the rate was 8-9 per cent between 1972 and 1979/80. The Bolivian experts are counting on an 0.9 per cent increase in consumption in 1983, 3 per cent in 1984 and 5 per cent in 1985, while a 7 per cent level will be reached only from 1986. These may be serious trends for all the groups that will have negative repercussions on the capital goods industry. Moreover, the financing capacity of these countries is relatively limited and programmes will remain dependent on bilateral and multilateral financing possibilities.

(c) Strategies

(i) Constraints. The country case studies refer to the following constraints:

- Restricted markets, which are moreover affected by the crisis through which these countries are passing;
- The extra cost of equipment, which is due more to the apprenticeship factor than to the restricted market;
- Financing both for capital investment and for components and raw materials;
- The lack of a long-term strategy.

Table 10. Bolivia and Tanzania: Installed capacity and consumption of electricity

	Bolivia					Tanzania				
				Annual growth rate (per cent)					Annual growth rate (per cent)	
	1972	1982	1990	1972-1983	1983-1990	1972	1982	1990	1972-1983	1983-1990
Consumption (GWh)	798	1,503		5.9		400	720	...	6	...
of which (per cent)										
- Industry		56*				70	53		3.1	
- Others		44				30	47		10.8	
Installed capacity (MW)	272	539	786	6.4	5.5	121.8	388.3	...	12.3	...

* 25% industry, 31% mining.

Source: UNIDO country case studies.

(ii) Activities and products. Software activities:

- Maintenance: Even if these activities seem to have been mastered by the two case study countries Bolivia and Tanzania, it seems that many problems still remain, owing to the diversity of equipment, the lack of foreign exchange for the import of spares and the limited capacity of some engineering workshops. The work is done by local personnel trained through technical assistance by the equipment supplier.

- Consultancy services: There is a noticeable difference between Bolivia and Tanzania. In Bolivia, ENDE (Empresa Nacional de Electricidad SA) has since 1960 had a consultancy service that carries out forecasts, feasibility studies and supervises purchases of equipment and assembly. In 20 years it has been possible to attain a national content level of 50 per cent. Tanzanian independence dates only from 1962 and the Government Company was set up in 1964. Foreign consultants still play a considerable part. These two contrasting cases show that over a period of ten years it is possible to make progress in mastering these activities provided that there is strict planning. In practice, it is a question of passing rapidly from a situation in which the foreign consultant works with nationals (the case in Tanzania) to one in which the activity of the prime contractor is in the hands of nationals assisted by foreign consultants (Bolivia).

- Project engineering activities (power stations, stations, lines): In the coming ten years, it does not seem to be possible to develop this activity in the countries in question.

- Wiring, assembly, civil engineering and equipment: For these countries one must definitely envisage a development period of ten years. For this purpose, it seems to be possible to fix the following objectives: Wiring and manufacture of low- and medium-voltage switchboards. The example of Cameroon, which has a company (Entrelec) with a staff of 200 persons making switchboards is significant. This is an activity that creates many jobs and which can provide training for high-quality electrical manpower. Moreover, the cabinets are manufactured from folded sheet metal, so that very little capital investment is needed for the manufacture. Participation in civil engineering. In this field also, Bolivia and Tanzania present two contrasting situations. In Bolivia, national participation has reached 70-90 per cent in the field of studies, execution and supervision. There are local companies in Tanzania, but their resources are still limited, so that foreign companies have to be used. Over a period of 10 years, all the countries in the group should be able to master civil engineering activities. Assembly. A large part of the assembly work should be mastered locally over a period of 5-10 years. Equipment. The main problem is the size of the market. As an example, it seems to be generally accepted that the minimum series for distribution transformers is 800-1,000/year and 4,000-5,000/year for electric motors, using relatively recent Western technology. Each market is therefore very close to the critical size.

Systematic studies for these countries should be carried out for the following products:

- Wooden and concrete poles as well as metal framework pylons;
- Distribution transformers, electric motors and miscellaneous medium voltage apparatus;

- Bare or insulated wire and cables for low and medium voltage. This would foster familiarization with copper, aluminium and plastics technologies.

(iii) Implementation. First of all, it seems to be necessary to endeavour to remove the principal constraints:

- Market constraints. Some measures can be suggested to develop markets; temporary customs protection measures, credits for the purchase of raw materials and components for motors, transformers and measures to protect public contracts. It also seems to be necessary to think in terms of adapting technologies.15/

  In the context of the implementation of a long-term strategy, it should be possible to develop planning and forecasting units within each national electricity company.

- Financing constraints are unfortunately difficult to remove, unless priority is given at international level to the electrification of the developing countries.

- The mastering of technology. At the domestic level, progress in the mastery of technology is achieved through a training policy and by measures to increase the capacity for the assimilation of technology, such as participation in the studies made by foreign consultant engineers, full participation in the assembly and start-up of the installations on the part of the national senior staff and technicians.

15/ The example may be quoted of a project for the manufacture of electric motors in Kenya using cast stators and flanges, which has the two advantages of reducing the pro tability threshold and making it easier to master the technology. In Europe, the stators of standard motors are made by pressure casting, which makes large production batches and a higher level of technological mastery necessary.

A foreign technological input is indispensable to supplement the domestic measures. This necessitates the selection and choice of partners and the regulation of technological transfer.16/

- Links with the capital goods sector. This sector is still in an embryonic state in these countries, but nevertheless links can be identified on the basis of the following technical paths:

  - Fabricating: manufacture of pylons and tanks;
  - Sheet metal and metalworking: manufacture of fittings, section insulators, and transformer tanks;17/
  - Foundry, forge: electric motor components.

Thus, it is at the level of the sector itself that inter-industry linkages can be created. Less importance should be attached to upstream linkages, with iron and steel, copper and aluminium metallurgy than according to the case studies. These countries are too small to engage in very capital intensive upstream activities that create few jobs.

The role of the Government. Government intervention should have the following objectives:

- To promote the establishment of offices for planning studies and monitoring projects;
- To regulate the transfer of technology;
- To give preferential treatment to national products in public contracts;

16/ In 1972, Bolivia introduced legislation on the import of technology. A Directorate for Standards and Technology was set up at the same time.

17/ This multi-purpose workshop is proposed in the Bolivian case study.

- To propose selective financing;
- To carry out an active promotional policy in the field of capital goods;
- To promote training and propose measures for national assimilation of imported technology.

3.2.4 Group 4. Medium-sized market, medium capacity

Cuba, Ecuador, Ghana, Iraq, Ivory Coast, Kenya, Democratic Republic of Korea, Tunisia, Saudi Arabia, Sri Lanka, Syria, Zambia, Zimbabwe.

(a) General characteristics

Table 11 gives information on the market for certain products and existing production for some countries. It will be noticed with regard to this group of countries that electric power production lies mainly between 3,000 and 5,000 GWh (except for Kenya and Tunisia, the countries have a per capita electricity production of over 300 kWh/year), so that the markets are still close to the critical size but should develop in the coming 10 years.

Other characteristics will give a clearer picture of this group of countries:

- They have a middle-range per capita income (Ivory Coast, $US 1,200; Syria, $US 1,570, Tunisia, $US 1,430, etc.)

- Manufacturing industry has developed to a certain extent and is diversified (chemical industry, capital goods industry, etc.). Its share of GDP is in the order of 10-15 per cent, and higher in certain cases (Syria, 26 percent; Zimbabwe, 27 per cent).

- The rate of urbanization is high: 40-60 per cent, with some exceptions: Kenya (15 per cent), Zimbabwe (26 per cent).

- Electrification has made progress: 6 countries out of 13 have a per capita rate of electrification above 500 kWh/year.

Table 11. Some statistical data on seven countries belonging to group 4

Country	Population (million)	Electricity production (GWh)	Per capita production (kWh/year per capita)	Imports of electric power equipment ($US million)	Market data (units)	Production
Zimbabwe	7	4,500	640	17	1,200 distribution transformers	Wires and cables Transformers and circuit-breakers Electric motors Pylons
Tunisia	6.5	2,700	415	94	800 to 1,000 distribution transformers	Medium voltage cables Distribution transformers 1,000 to 2,000/year - 50% export.
Kenya	17	1,600	94	30 to 50	350 to 500 distribution transformers	Project: Distribution transformers 1,000 to 2,000/year - 50% export
Ivory Coast	8.5	1,800	210	40 to 50		Project: Distribution transformers 1,000/year
Syria	9	4,400	490	100	300 to 500 distribution transformers	...
Iraq	13.5	8,000	590	1,080	1,500 distribution transformers	
Ecuador	9	3,200	360	60	1,000 to 1,500 distribution transformers	

Finally, countries in this group have developing some capital goods industries. In the case of Tunisia this is illustrated by table 12. In the case of Kenya the number of jobs in the capital goods sector is estimated at 16,000, distributed as follows:

Metal products	7,215
Mechanical machinery	528
Electrical machinery (including radio and television)	4,991
Shipbuilding and repair	1,087
Automobile assembly	2,469
	16,290

The principal production activities are as follows:

- Miscellaneous metal goods (nails, tacks, staples, also structural metalwork and boilermaking).

- Production of simple agricultural machines and tools.

- Assembly of radios, television sets and electrical household appliances.

- Assembly of automobiles with local production of some equipment: windscreen wipers, batteries, springs, tyres, radiators.

- Construction of some simple tea and coffee processing machinery.

Therefore, no mechanical or electrical machinery is yet being produced. The situation is rather different in the case of Zimbabwe where a relatively well endowed electric power equipment industry exists. Producing goods as follows:[18/]

. . . .

18/ Project documents submitted at the SADCC Conference of 27 and 28 January 1983.

Table 12. Tunisia: the mechanical, electrical and electronic engineering industries and the electric power equipment industry

	Structure of production	Per cent of total production
1.	Capital goods	
	Structural steelwork, boilermaking, bus and lorry bodies	7.7
	Internal combustion engines	1.9
	Transformers, electric motors	9.0
	Shipbuilding	2.5
	Sub-total	21.1
2.	Intermediate products	
	Iron and steel	23.0
	Metallurgy	6.3
	Foundry	3.0
	Miscellaneous metal products	12.0
	Batteries, cables	4.0
	Sub-total	43.8
3.	Durable consumer goods	
	Automobiles	21.4
	Household appliances	4.0
	Radio and TV	4.2
	Electrical household appliances	5.5
	Sub-total	35.1
	Total production	100.0

4. The electric power equipment industry: (main characteristics)

<u>Distribution transformers</u>: 16 kVA to 2,500 kVA/36 kV
Production: 3,000/year, incl. 50 per cent for export
Origin: 1967, national technology
National content: 45 per cent

<u>Electric motors</u>: 5,000/year, incl. 10 to 20 per cent for export
Origin: 1967
National content: 51 per cent

(1) Electric wire and cables. The only Zimbabwean producer is Central African Cables Ltd., of which the British BICC Group is a major shareholder.

Central African Cables produces:

- Bare copper wire

- Plastic insulated electrical cables: 16 mm^2 and 185 mm^2, up to 3.3 kV

- PVC insulated cables: for automobiles, telephones, remote control systems, flexible cables, cables for welding sets.

- Aluminium twisted cable, with steel jacket or PVC insulation.

Installed capacity is 3,900 tons/year for copper wire and cable and 2,900 tons/year for aluminium cable.

(2) Transformers and circuit-breakers. The bulk of requirements for transformers (1,200/year) and low voltage switch and switchgears (250) of Zimbabwean electricity companies are provided by South Wales Electric, Harare, a subsidiary of the British Hawker Siddeley Group.

This enterprise manufactures:

- Distribution transformers up to 1,000 kVA
- Power transformers up to 50 MVA and 132 kV
- Contactors and other low voltage appliances up to 11 kV.

It is capable of satisfying 95 per cent of Zimbabwean needs. As far as transformers are concerned, the local content of production is 80 per cent; for contactors, it is 65 per cent. A small part of the output is exported to Zambia and Malawi.

(3) Electric motors. Motors from 0.5 to 250 hp have been produced locally for 8 years, by RELMO Electric Motors. RELMO is a subsidiary of the Mashonaland Holdings Group, which also controls ME WIRES. ME WIRES also supplies enamelled wires to RELMO, which also has its own foundry.

RELMO works under licence from General Electric (UK). The local content of the motors produced has risen in recent years from 50 to 88 per cent. RELMO makes three-phase and single-phase motors of international quality conforming to the recommendations of the International Electrotechnical Commission.

Installed capacity is for 20,000 motors/year. At the moment, production is 10,000 units and should rise to 16,000 in 1985. In parallel, the production capacity for enamelled wire by ME WIRES should increase from 200 to 300 tons.

(4) Transmission pylons. There are two manufacturers of transmission pylons in Bulawayo capable of supplying 5,000 tons/year. Their capacity could easily be increased.

(b) Energy resources and policies

For most of the countries in this group, access to energy resources is not a major obstacle; petroleum (Iraq, Saudi Arabia), hydroelectricity (Kenya), coal (Democratic Republic of Korea).

The rate of electrification is already high and is linked particularly to the development of the manufacturing industry and to the rate of electrification of households. Furthermore, the countries are pursuing their electrification efforts, which have been going on for more than 20 years, thus regularly expanding the market for electric power equipment.

Finally, unlike the countries in the preceding groups, access to domestic and international financing does not seem to pose serious problems. There are thus no, or very few, constraints in this field.

(c) Strategies

For these countries, whose markets are just over the critical threshold, the prospects in the coming ten years are important and the countries should engage resolutely in the development of the sector.

(i) Constraints. The size of the markets necessitates judicious choices and identification of export or re-export/countertrade possibilities with industrial partners.

External financing has a tendency to be coupled with a system of standards, consultant engineers and equipment. The development of engineering companies and technological unpackaging should make it possible to remove this constraint.

The use of foreign technologies is indispensable, making it necessary to strengthen the bargaining power.

(ii) Activities and products. For this group of countries, the operation and the repair and maintenance of power stations and substations should not raise any special problems. It can be reported that, because of experience acquired in the maintenance and rewinding of transformers, Tunisia was able to commence the production of transformers in 1968, on the basis of national technology.

Progressive mastering of the consulting engineering and engineering fields seems to be a compelling need. For a certain number of countries, this has already been achieved as far as engineering consultancy is concerned.19/ In others, study offices are being established in the national electricity

. . . .

19/ In this field, Colombia (which belongs to group 5), has 85 per cent mastery of engineering consultancy (study, design, monitoring or purchases, etc.) and 1,600 persons are employed in this activity.

companies. One can quote the experience of Kenya, which has used the services of the Canadian technical co-operation agency ACDI to create a planning and monitoring unit in EAPL (East African Power and Lighting Co.) and the experience of the Ivory Coast, which asked EDF International (France) for technical assistance.

As far as the design and construction of power stations, lines and substations is concerned, it is conceivable that detail engineering should have a progressively increasing local content.

It should be possible to achieve a 50 to 80 per cent national content in civil engineering and assembly, depending on the country in question even if ad hoc and selective foreign technical assistance is still necessary.

With regard to the production of equipment, the situation in three countries, Kenya, Tunisia and Zimbabwe, may serve as an example.

In Kenya, wiring and the manufacture of low and medium voltage switchboards have been developed by the importers themselves, who are generally major foreign enterprises: ASEA, Klockner, Brown Boveri. Cables up to 185 mm^2, PVC-covered aluminium and copper conductors are manufactured locally. There are no projects for high voltage cables. As far as distribution transformers are concerned, the history of the project is instructive in many respects.[20/]

The market for distribution transformers is estimated at 750 units per year. This project is included in the Plan, but the initiative of Brown Boveri is the determining factor. The

20/ Industrial co-operation with developing countries on the basis of rural electrification, op. cit.

Brown Boveri Group transformers are produced in Berlin and some years ago BBC decided not to expand its production capacity there but to relocate it. Kenya then seemed to be the most suitable site. In 1978, a feasibility study had been carried out for a production capacity of 1,000 - 2,000 transformers for the domestic market and export. The financial arrangements envisaged were BBC and DEG (a financing agency of the Federal Republic of Germany) on the Federal Republic of Germany side, and, on the Kenya side, EAPL and development banks. The project is blocked at present for various reasons, but it is almost certain that, in two or three years, local production will have started.

Similar remarks apply to the project for electric motors, pumps and diesel engines: an enterprise under Kenyan law, 49 per cent of whose capital is held by a major Indian company KIVLOSKAR LTD (machine tools, pumps, etc.), intends to produce electric motors, pumps and diesel engines.

The market for electric motors is estimated at approximately 4,000 units in powers below 25 hp. The national content should reach the 70 per cent level, according to the following pattern:

- Import of CKD kits: assembly, painting and inspection operations;
- Winding with local copper wire, a sample of which has already been sent to India for testing;
- Machining of certain mechanical parts;
- Casting of stators and flanges in Kenyan production plants and machining (samples of castings are being tested in India).

The market for pumps is estimated at 10,000 units. The national content will be progressively increased according to a pattern similar to that for electric motors.

Diesel engines - mainly assembly.

Tunisia: Local production of distribution transformers began in 1970 in a company with Government capital, at the instigation of the Société Tunisienne d'Electricité (STEG, a Government company). The technology is national and at the moment 50 per cent of the output is exported to neighbouring countries, such as Libyan Arab Jamahiriya and Algeria. Local production of electric motors also began in 1970. In accordance with STEG's requirements, the Tunisian company was able to improve the quality of the products.

Zimbabwe: Production is still more diversified as there is production of power transformers up to 50 MVA and of contactors and miscellaneous apparatus up to 11 kV.

These three examples show that, for the group as a whole, production should in time cover the following fields:

- Medium voltage wires and cables;
- Medium voltage equipment: transformers, apparatus, motors, switchboards, substations;
- Poles and pylons;
- High voltage equipment. The experience of Zimbabwe and the projects in Tunisia show that advances are possible in the field of transformers;
- As far as power stations are concerned,[21/] some parts are considered to be of low or medium complexity in the three technical paths. The objective to be attained by means of technological unpackaging is the manufacture of the parts and sub-assemblies that are of low and medium complexity.

. . . .

21/ For more details see table 4.

(iii) Implementation. National policy for the mastering of technology uses the following expedients:

- Selective financing in order to encourage the development of a capital goods industry;
- A technological policy that includes the choice and control of imported technology, technological unpackaging, by avoiding turnkey contracts, for example, and the establishment of a testing laboratory;
- A high-level training programme.

On a national basis of technological mastery, it is then possible to import technologies whose assimilation will be favoured by internal effort. Foreign technologies can be acquired by the purchase of licences or by joint ventures.

Linkages with the capital goods sector must be intensified because the components of power stations are produced by fabricating and machining and the production of motors uses foundry and forge techniques.

The Government has an important role to play by promoting new projects (e.g. STEG in Tunisia) and by studying them, seeking partners, etc., scheduling public purchasing programmes, adopting temporary protection measures for local industry, and by promoting a technological policy (establishment of engineering companies, avoidance of turnkey arrangements, establishment of laboratories for testing and experimentation with materials for electrical equipment).

3.2.5 Group 5. Medium-sized market, low capacity

Bangladesh, Burma, Ethiopia, Zaire. In the typological analysis, these countries were singled out because of their large population. However, in section 3.1 it was pointed out that, from the point of view of a strategy, this group could be included in that of countries with medium-sized population and small markets that had small capital goods industries or none.

The main element that can influence strategy is the size of the potential market,22/ in view of the needs and size of these countries. However, the size of the markets must be considered relative because the development of electrification is almost totally dependent on external financing.

3.2.6 Group 6. Large market, high capacity

Algeria, Colombia, Egypt, Indonesia, Iran, Morocco, Nigeria, Pakistan, Philippines, Thailand, Turkey, Chile, Malaysia, Peru, Venezuela.

(a) General characteristics

The 15 countries belonging to this group while having the characteristics of a large population, a large potential market (annual electric power consumption is between 10,000 and 20,000 GWh, or 3 to 4 times greater than in the previous group) and a fairly considerable production capacity for capital goods in common, a more refined analysis shows that there is also great diversity. As far as size is concerned, there are 3 large countries (Indonesia, Nigeria, Pakistan) and 11 countries whose population lies between 20 and 50 million inhabitants.

The per capita income ranges from $US 400 for Pakistan to $US 4,200 for Venezuela and the electrification rate varies greatly. Six countries having a rate above 500 kWh/year per capita, 7 having a rate of 100-500 kWh/year and two with a rate below 100 kWh/year.

On the other hand, there are certain common characteristics with regard to the place of manufacturing industry and development. Industry accounts for 15 to 20 per cent of the GDP. Some countries already have a long industrial history; in others, development is more recent.

22/ It was doubtless with market prospects in mind that the manufacture of transformers was undertaken in Bangladesh with technical assistance from the Soviet Union. However, national industry supplies only 5 per cent of national needs. There is also production of wires and cables up to 11 kV.

There is a substantial market for electric power equipment which resulted in the development of a local industry, but the market is also largely supplied by import (in the order of $US 300 million, with two extreme cases, namely, Morocco, with $US 15 million imports and Nigeria with $US 570 million imports).

Finally, these countries have already developed the nucleus of an electric power equipment industry (see tables 13, 14, 15 and 16 on Indonesia, Egypt, Colombia and Pakistan respectively). On the basis of these tables, the following general remarks can be made:

The production of low and medium voltage equipment is widespread in all countries, even though production is of recent origin in some of them (Algeria, Egypt, Indonesia, Morocco, Nigeria).

The production of high voltage apparatus is found only in a few countries; for two years Indonesia has been producing high voltage transformers, Egypt will do so by 1985, while Chile and Peru are also producing 160 kV transformers.[23/]

However, in the power station field (boilers, turbines, alternators, control equipment), substations, equipment for transmission (disconnecting switches, circuit breakers, transformers) there is not yet any national production.

In conclusion it appears that:

- The medium voltage distribution sector has been practically mastered;
- Nothing has been achieved in the field of equipment for production and transmission (very high voltage, high voltage).

23/ Nota sobre la capacidad de producción de bienes de capital en algunos países latino-americanos (Note on the production capacity for capital goods in some Latin American countries) - Siderurgica latino americana, No. 277, May 1983.

Table 13. Indonesia: Data on the electric power equipment industry

3,200 persons	Production began in 1969	
	1969-1974 – Production on the basis of maintenance workshops	
	1974-1979 – First major development	
	1979-1984 – Consolidation phase	
Meters......................:	4 enterprises capacity 1,000,000 units	
Conductors and cables.......:	14 enterprises capacity 20,000 tons	
Transformers - distribution:	9 enterprises (production began in 1977) capacity 20,000 units	Production 1981: 4,000 units
high voltage:	(Merlin Gerin licence) production began in 1981	Production 1983: 20 units
Apparatus, substations, switchboards (low voltange, medium voltage)............:	Several enterprises	
Electric motors............:	9 enterprises (production began in 1977) capacity 15,000 to 20,000 units	
Diesel engines.............:	5 enterprises capacity 88,000 units	
Pumps......................:	7 enterprises capacity 28,000 units	
Boilermaking...............:	13,000 tons	

Table 14. Egypt: Data on the electrical equipment industry

Name of company	Ownership	Employment	Production	Technology	History
ELNACO	99% public	820	Distribution transformers 1972 : 300 units 1983 : 1,100 units	FRG (Trajo Union)	Established 1957 - nationalized 1961 Licence with Trajo Union
Egyptian Electrical Cables Company	Public	3,000	Medium voltage cables (11 kV): 11,000 t Low voltage cables: 12,000 t Telephone cables, insulated wire	Parisian cables factory	1954 (private), 1961: nationalization 1955 - insulated cable and wire 1960 - underground cables for low and medium voltage 1981 - expansion of the factory
EGEMAC	49% EL NASR 41% SIEMENS 20% DEG (FRG)		Medium voltage posts and substations Medium and low voltage switchboards Insulators	SIEMENS	1978 - Joint venture with Siemens
ARABB	70% Arab Contractors 30% Brown Boveri		Medium and low voltage switchboards and equipment	Brown Boveri	1979

- Aluminium and copper conductors are produced in a public sector enterprise (Licence FRG, Hungary, Switzerland)

- Poles and pylons (very high voltage) are produced in two public sector structural metalwork enterprises.

Table 15. Colombia: Data on the electric power equipment industry

---

Boilers, pylons, boilermaking (ISIC 38 13): Employment: 6,400 persons 164 establishments $\frac{VA}{P} = 50\%$

There are seven enterprises producing electric power equipment including one with a staff of 2,400

The first ones date from 1949

Motors and turbines (ISIC 38 21): Employment: 129 persons 4 establishments $\frac{VA}{P} = 36\%$

65 per cent of intermediate products are imported

One enterprise produces small turbines (120 kW) - established in 1964.

Motors, generators, equipment, transformers, etc. (ISIC 38 31): Employment: 4,500 persons
63 establishments $\frac{VA}{P} = 50\%$

50% of intermediate inputs are imported

The first enterprises date from 1960

About 10 large enterprises, including SIEMENS, General Electric.

Electric motors	:	One large enterprise and two small ones
Transformers (1974)	:	One large enterprise, medium and high voltage.
Posts, substations, etc. (medium and low voltage)	:	11 enterprises

---

Table 16. Pakistan: Data on the electric power equipment industry

Products	Enterprises (number)	Installed capacity	Capacity utilization rate (per cent)	Demand in 1982
Transformers up to 33 kV	8	25,000 MVA	40	13,000
Transformers over 33 kV	1			70
Apparatus and switchboards	5		30 to 50	
Generators up to 650 kVA	1	100,000 kVA	20	
Electric motors	20	700,000 hp	30 to 40	
Low and high voltage cables	7	20,000 tons	20	
Copper and aluminium conductors	8	30,000 tons	50	
Meters	6	758,000 units	30	
Insulators and porcelain	1	3,000 tons	60	
Fuses 11 kV	7	300,000 units	20	

(b) Energy resources and policies

The country case studies give important information on this point (table 17).

In the case of Egypt, installed capacity rose from 3,948 MW in 1972 to 6,182 MW in 1983 (annual growth rate of 4.1 per cent). Projections for 1990 show an annual growth rate of 8.4 per cent. Hydroelectricity represented 60 per cent of installed capacity in 1972 and 40 per cent in 1983; it will represent 20 per cent in 1990 and 19 per cent in the year 2000, when nuclear energy will account for 35 per cent and conventional thermal energy for 46 per cent. As far as production is concerned, it appears that in 1952 production was 930 GWh, that is to say, of the same size as actual production by Tanzania in 1983, or by Bolivia in 1975.

The data for Colombia are similar to those for Egypt, namely, consumption of about 20,000 GWh in 1983 and 35,000 in 1990 (8.5 per cent growth rate), with industry representing only 32 per cent of consumption in 1983 as against 44 per cent in 1972. Installed capacity in 1983 is 5,440 MW, 64 per cent being of hydroelectric origin; the position of hydroelectricity will be strengthened by 1995 (80 per cent hydroelectricity).

Consumption in Pakistan is lower than that of the above two countries (14,150 GWh in 1983); 47 per cent for industry as against 63 per cent in 1972. Installed capacity is 5,024 MW, 50 per cent of hydroelectric origin, 47 per cent of thermal origin and 3 per cent of nuclear origin; in the year 2000 the nuclear production sector should represent 12 per cent of installed capacity and hydroelectricity 50 per cent.

Finally, in the case of Indonesia consumption in 1983 was identical with that of Pakistan (14,256 GWh).

These figures show that for this group of countries:

Table 17. Installed capacity and electric power consumption

	Egypt					Colombia					Pakistan				
				Annual growth rate (per cent)					Annual growth rate (per cent)					Annual growth rate (per cent)	
	1972	1983	1990	1972-83	1983-90	1972	1983	1990	1972-83	1983-90	1972	1983	1990	1972-83	1983-90
Consumption (GWh)	6,169	20,735	37,900	11.6	9.0	8,878	19,520	34,550	7.4	8.5	5,408	14,147		9.1	
Including: (per cent)															
- Industry	63	60		11.1		44	32		4.0		63	47		6.3	
- Others	37	40		11.9		56	68		9.3		37	53		12.6	
Installed capacity (MW)	3,948	6,182	10,893	4.1	8.4	2,491	5,440	9,646	7.3	6.7	1,837	5,024	11,090	9.5	11.9

- Consumption is between 10,000 and 20,000 GWh, or 3-4 times less than in the Republic of Korea, 5-6 times less than in Mexico and 8-10 times less than in Brazil and India.

- The energy resources are of diverse nature. In Egypt, first of all hydroelectricity and then conventional thermal energy in about the years 1980 - 1990, followed by nuclear energy in the year 2000 (35 per cent). In Colombia, hydroelectricity remains the most important resource. The same applies to Pakistan, where, however, nuclear energy could represent 12 per cent of installed capacity.

- It should be added that in these four countries Government companies for the production, transmission and distribution of electric energy were set up in the years 1955-1960:

Egypt	:	1954	Establishment of the Egyptian Electricity Commission
		1964	Establishment of the Ministry of Electric Power
Colombia	:	1946-1962	Establishment in Colombia of production and distribution enterprises
		1967	Establishment of ISA (Interconexion Electrica S.A.)
		1976	Establishment of the Fondo de Desarollo Eléctrico (Electricity Development Fund)
Indonesia	:	1961	Establishment of the Government Electricity Company
Pakistan	:	1958	Establishment of WAPDA (Water, Power Development Authority)
		1951	Nationalization of KESC (Karachi Electricity Corporation Limited)

Finally, as far as rural electrification is concerned various instruments have been created, but much more recently:

Egypt 24/	:	1971	Rural Electrification Authority
Pakistan 25/	:	1977	Commencement of a large-scale rural electrification programme.

....

24/ 80 per cent of the rural population have access to electricity.

25/ 25 per cent of the rural population have access to electricity.

In conclusion, all these countries have large-scale and diversified energy resources except Morocco, Turkey and the Philippines. Energy strategy should be based on a continuation of the electrification programme, particularly, rural electrification.

On the other hand, the industrial development that these countries intend to pursue as a very important component of their development strategy should bring increased consumption of electricity. Finally, the search for greater energy efficiency will result in increasing the role of electricity.

All these factors should bring about a substantial demand for electric power equipment.

(c) Strategies

(i) Constraints. They are essentially of three kinds.

Financial constraints. The electric power equipment sector will be developed in the future by means of advanced technologies leading to high investment costs (enterprises, laboratories, testing centres, training of highly skilled manpower).

Technological constraints. In the coming ten years, these countries must go through an important stage. It is necessary to commence the production of power station equipment, high and very high voltage equipment. It is therefore necessary to locally organize the process of technological mastery, which will require a national effort and a policy for access to foreign technologies, which, at this level of complexity of equipment, is the prerogative of a few large transnational companies.

Institutional constraints related to policymaking. When they reach this stage, the countries will not be able to make progress by relying only on market forces. It is significant that Colombia decided to give particular attention to the capital goods industry in the 1983-1987 Plan. All the case studies stress many of the causes for the lack of development of the sector; the absence of a clear decision and of a national policy for the development of the capital goods sector.

(ii) Activities and products. Study and engineering activities will have increasing importance in the overall process for mastery of the sector. The experience of Mexico and, above all, the Republic of Korea, as shown in the case studies, bear witness to the permanent concern of the decision-makers to make rapid progress along these lines. In Colombia, although there has been no firm decision in this field until recently, up to 85 per cent of consultancy services (forecasting, preliminary studies, control of foreign engineering companies) are provided by Colombian companies.

In Egypt, a new national engineering company was set up in the Ministry of Electric Power to develop the activities of planning, feasibility studies and project management. The establishment of this company is the culmination of a process that began in 1954 with the establishment of a technical office responsible for the same functions, which, throughout its history, has been assisted successively by EDF of France, the USSR (the Aswan Dam and study of long-term electrification prospects).

The development of engineering activities requires a different approach. It necessitates in the first case rejection of the turnkey or product-in-hand contract and adoption of the technological unpackaging approach. A decree of 1976 regulates these procedures in Colombia. In this field, the implementation patterns are very diverse.

With regard to equipment, the case studies have shown that the medium voltage equipment and apparatus are on the whole manufactured locally. The objective to be attained is thus to commence the manufacture of power station components and medium and high voltage equipment (substations, lines, etc.)

The experience of the Republic of Korea and Mexico shows that difficulties in manufacturing power station components are not insurmountable and that the national content may rapidly reach 20-30 per cent. On the other hand, the manufacture of parts of turbines and alternators calls for a very specific approach and thorough study. This manufacturing activity calls in particular for the establishment of heavy plant (machining, forging, foundry). As far as apparatus is concerned, the prevailing impression is that the approach will be through high and very high voltage transformers, high-power electric motors, generators and finally selection insulators and circuit-breakers.

However, at the same time that new products are launched, it is necessary to make a special effort, both to improve the quality of products, and to increase the national content of the products already being manufactured.

(iii) Implementation

Technology. In the field of the national mastering of technology, one can enumerate some measures that have been taken by the different countries:

- Preparation of a plan for the development of the capital goods sector;
- Legislation concerning contracting procedures in order to progress from the turnkey stage to technological unpackaging;
- Legislation concerning the establishment of national engineering companies;

- Legislation for the protection of national industry;
- The establishment of research, study and control centres. In this respect, Egypt has the National Research Centre, the Centre of Industrial Design, and the High Voltage Research Centre responsible to the Ministry of Industry and Power.
- Legislation concerning access to foreign technology;
- Preparation of a programme for training in the country itself and abroad.

Access to foreign technology is a compulsory step in connection with this type of equipment, which these countries will have to produce. The case studies seem to stress two procedures, while rejecting a third. The first two are related to the purchase of licences and the development of joint ventures and the third is related to the establishment in the country of subsidiaries of transnational enterprises in which the latter have a majority holding. This latter formula is rejected because the transfer of technology has not been ensured and was carried out badly. The example of Egypt is significant; until 1974, access to foreign technology was provided by the purchase of licences. Since 1974, the national authorities have promoted the establishment of joint ventures, which seem to guarantee better transfer of technology and which may be the basis for negotiations regarding the re-export of part of the output.

Linkages with the capital goods sector. In all the countries studied linkages are made with the upstream sector when there is an iron and steel industry, aluminium or electrolytic copper production and linkages are developed with the local industrial fabrication (foundry, forge, machining).

However, the trend is towards the organization of subcontracting relationships between the large enterprises and the small- and medium-scale enterprises in order to benefit to the maximum extent from economies derived from organization and specialization.

In Pakistan this question has been raised since 1965 when a proposal for a heavy electrical complex was launched. A first report dating from this period recommended the production of power transformers up to 132 kV, section insulators up to 132 kV, insulators, motors of 1,000 hp, traction motors and alternators up to 600 hp. A new study was made in 1974, without result, and a further one in 1976. In 1983, a Committee for the Heavy Electrical Complex was set up and a large number of firms were contacted in fourteen countries.

The role of the Government. The Government has a paramount role to play in this phase of development. Experience shows that this does not mean that all the enterprises must have Government capital, but it does mean that the authorities are there to originate ideas, promote, stimulate and recommend. It is necessary at one and the same time:

- To promote national engineering capability;
- To promote a capital goods industry;
- To work out a policy for access to technology;
- To work out a policy for public purchases;
- To encourage the private sector to invest in the electric power equipment sector.

3.2.7 Group 7. Semi-industrialized countries

Argentina, Brazil, China, India, Republic of Korea, Mexico and Singapore.

(a) General characteristics

These countries have reached such a stage of development that each country implements its own strategy. It therefore seemed to be preferable to elicit from the three country case studies (India, Mexico and Republic of Korea) the common points between these countries and the points in which they differ.

Production, consumption and sources of electricity (table 18).[26/] Mexico and the Republic of Korea have similar electricity production figures (900 and 1,000 KWh/year per capita), whereas India is still at a very low electrification level (170 kWh/year per capita) because of its huge population (690 million). India has the largest installed capacity (36,000 MW), followed by Mexico[27/] (20,000 MW) and the Republic of Korea (13,000 MW).

From the point of view of consumption, the highest growth rate was noted in the Republic of Korea (13.6 per cent per annum between 1972 and 1983) and for 1990, the growth rate forecast is 12.7 per cent. Mexico has had a growth rate of 7.9 per cent and India 5.6 per cent. In these three countries, industry and construction account for between 60 and 80 per cent of consumption.

In the Republic of Korea, the source of electricity (table 19) will change most between 1972 and 1990, thermal sources falling from 91 per cent in 1972 to 47 per cent in 1990, whereas nuclear energy will represent 39 per cent in 1990 and hydroelectricity 14 per cent.[28/] In Mexico, the share of hydroelectricity will drop sharply from 41 per cent to 28 per cent (1990), yielding its place to gas, geothermal and nuclear energy. In India, there was stability between 1971 and 1983.

The case studies on the Republic of Korea and India provide information on rural electrification. In the Republic of Korea, electrification reaches 99.4 per cent of the population. In India, during the Seventh Plan (1986-1990) it is expected to provide electricity for the operation of 2.25 million pumps.

26/ The Government production and distribution enterprise were set up at much the same time (India, 1956; Mexico, 1960; Republic of Korea, 1961).

27/ Installed capacity in Mexico was 500 MW in 1939, which is the present installed capacity of countries like Bolivia, Tanzania and Kenya.

28/ The more important place of hydroelectricity is due in particular to the development of a small hydro programme. 2,400 sites with a total capacity of 583 MW have been identified, 1,500 sites with a capacity of up to 100 kW, 760 sites of 100-1,000 kW and 107 of 1,000-3,000 kW.

Table 18. Installed capacity and electric power consumption

	Mexico					Republic of Korea					India				
				Annual growth rate (per cent)					Annual growth rate (per cent)					Annual growth rate (per cent)	
	1972	1983	1990	1972-83	1983-90	1972	1983	1990	1972-83	1983-90	1972	1983	1990	1972-83	1983-90
Annual consumption (GWh)	28,472	65,653			7.9	9,952	40,700		13.6	12.7	51,760	89,810		5.6	
Including: (per cent)															
Industry	72	72				89	83				70	62			
Others	28	28				11	17				30 a/	38 b/			
Installed capacity (MW)	8,113	20,212	8	8.5	7.6	3,872	13,115		11.7	7.8	16,889	35,389		7.6	

a/ Including 9 per cent agriculture and 21 per cent consumption by households.

b/ Including 16 per cent agriculture and 22 per cent consumption by households.

Table 19. The sources of electric power (per cent)

	Republic of Korea				Mexico					India	
	1972	1983	1990		1972	1983	1990	2000		1972	1983
Hydro	9	10	14	Hydro	41	33	28	30	Hydro	39	34
Thermal	91	76	47	Thermal	59	66	58	59	Thermal	56	63
Nuclear		14	39	Geothermal		1	2.5	2.5	Nuclear	5	3
				Gas			7	6			
				Nuclear			4.5	2.5			

(b) Studies and engineering activities

In the Republic of Korea, from 1960 to 1970 all the power stations and substations were purchased on a turnkey basis. In 1970, an instruction from the President of the Republic ordered the establishment of engineering companies. At the end of the 1970s, the country had 16 companies. In 1975, the Korea Electric Power Corporation (KEPCO) changed the nature of the contracts, abandoning the turnkey approach, which was considered to be incompatible with the national development of a capital goods industry.

At the moment, there are seven engineering companies. In the field of thermal power stations, the change came in 1976. Since that date, KEPCO has had a contract with a Korean engineering company, which subcontracts or enters into joint ventures with a foreign company. With regard to companies this is at a lower level than in the case of thermal power stations. In nuclear power stations, the Republic of Korea aims at very rapid progress in mastering engineering, as is indicated by the country case study. The rate of participation by KOPEC (Korea Power Engineering Company) will rise from 5 to over 70 per cent between the first and the eleventh power stations. Already, as from the fifth power stations, the turnkey approach has been abandoned.

As far as Mexico is concerned, CFE (Comisión Federal de Electricidad) has a directorate for studies and the construction of installations. CFE also relies on the national electricity research institute for the design and choice of equipment. In some cases, CFE uses the services of national engineering companies to carry out detailed studies. CFE has carried out standardization studies in order to obtain a single power station model for 300 MW power stations.

In India, at the beginning of the 1950s, feasibility studies were carried out by foreign consultants. However, since the beginning of the 1960s, Government companies as well as the Central Electricity Authority, have developed their own study offices. Engineering activities have above all been developed by the Indian enterprise BHEL (Bharat Heavy Electricals Limited).

There is thus a great similarity between these three countries as far as the importance attached to the mastery of the engineering and studies activity is concerned, which also entails the abandonment of turnkey contracts.

(c) The production of electric power equipment

India and Mexico have the oldest industries. In Mexico, production began in the 1940s. In 1944, the first large enterprise was set up, Industria Electrica de Mexico, with a licence from Westinghouse Electric for the production of distribution transformers, electric motors and distribution switchboards. Forty-five years later, this enterprise is producing transformers of 400 kV and 150 MVA, SF_6 circuit-breakers and electric motors of 5,000 hp. Important developments ensued after 1960; from about 1975 Mexico began to produce very sophisticated equipment: explosion-proof motors up to 1,000 hp, very high voltage transformers, SF_6 circuit-breakers, 300 MW boilers, water turbines (from 1983). Investments are in hand (Japanese licence) for the production of alternators and steam turbines up to 350 MW.

In India, the first production dates from the 1950s and was mainly based on British companies and later on enterprises from other European countries. In about 1950 the Government decided to set up public companies to manufacture equipment for the production, transmission and distribution of electric power. A first unit was established in 1960 and the other three between 1965 and 1967. The development of the products is shown in table 20. All the equipment is manufactured in India. The 500 MW boilers will be produced in about 1985 to 1986. The 200-1,000 MW alternators and turbines are produced under licence from KWU (Federal Republic of Germany).[29/]

In the Republic of Korea, the industry is of more recent origin. The first low and medium voltage equipment dates from 1965-1970, but it seems that progress has been much more rapid and is very closely linked to the history of

. . . .

29/ Historically, the following are the degrees of national content for production equipment (boilers, turbines, alternators): up to 1970, imports; from 1970-1975, national content 10-15 per cent; 1975-1980, national content 25-60 per cent; from 1980, national content above 60 per cent.

Table 20. India: The electrical equipment industry

Growth of product-mix

Energy sector		1964-1969	1969-1974	1974-1979
Thermal/Nuclear System			+	
Thermal sets	30 MW	+	+	
(TG & Boiler)	60 MW	+	+	+
	100 MW	+	+	
	110 MW	+	+	+
	120 MW		+	+
	210 MW		+	+
	500 MW			+
Nuclear sets	236 MW		+	+
Valves		+	+	+
Soot blowers			+	+
Fans			+	+
EPS				+
Pumps		+	+	+
Motors		+	+	+
Heat exchangers			+	+
Pipes and fittings				+
Hydel system				+
Hydro sets		+	+	+
Pump turbines				
Micro hydel sets				
Bulb turbines				
Transmission/Dist. system				+
Transformer			+	+
Switchgear		+	+	+
Capacitor			+	+
Insulator				+
Control equipment				+
Devices				+
Controlgear				+
Energy meters				+
Solar energy equipment			+	

+ Indicates the existence of the particular product in the company product-mix.

Table 20. India: The electrical equipment industry (cont'd)

Industry sector	1964-1969	1969-1974	1974-1979
Thermo-mechanical system			+
Industrial TG	+	+	+
Turbo-compressor	+	+	+
Centrifugal compressor		+	+
Drive turbines	+	+	+
HSDT			+
Industrial boilers	+	+	+
Valves	+	+	+
Pumps	+	+	+
Motors		+	+
Control equipment			+
Controlgear			+
Electric drive and control system			+
AC machines	+	+	+
DC machines	+	+	+
Oil rigs			+
<u>Transportation sector</u>			
Traction equipment		+	+
Control equipment			+
Controlgear			+
<u>Others</u>			
Gray iron castings	+	+	+
Seamless steel tubes			+
Steel castings			+
Free forgings			+

\+ Indicates the existence of the particular product in the company product-mix.

the Government enterprise KHIC (Korea Heavy Industry Company), set up in 1962. The production of turbines and alternators began in 1980 and the objective is to rapidly reach a level of 55 per cent national content. Towards the end of the 1970s, power transformers (345 kV) and SF_6 circuit-breakers (170 kW) were produced.

(d) Some macro-economic data

In India the production of electric power equipment was $US 850 million in 1978, imports were $US 140 million and exports $US 50 million. The organized sector includes 150-200 enterprises, including 30 in transformers, 30 in cables and 30 in electric motors.

In Mexico, production of electric power equipment in 1978 was in the order of $US 1,900 million (7 per cent of GDP) or twice that of India. In 1983, the sector included 1,800 enterprises and was employing 165,000 persons. Employment increased 7.8 per cent per annum between 1971 and 1982. Small- and medium-scale enterprises represent 40 per cent of production.

The overall data of the Republic of Korea are related to the entire sector of the mechanical, electrical and electronics engineering industries, representing a value of production of $US 14.5 billion and 544,000 jobs. Employment increased 4 per cent per annum between 1977 and 1981. More significant is the development of imports and exports[30/]:

Imports			Exports			Imports/Exports ratio	
million $US 1978	million $US 1982	Annual growth rate (per cent)	million $US 1978	million $US 1982	Annual growth rate (per cent)	1978	1982
597	750	5.8	149	370	25	4	2

30/ For all of the products covered by the study, i.e, divisions 711, 714, 716, 718, 771, 772 and 773 of SITC Rev.2.

The annual growth rate of imports was 5.8 per cent, that of exports was 25 per cent and the import/export coefficient fell from 4 to 2 over the period. The opposite phenomenon may be observed in Mexico, where the import/export ratio rose from 3.7 in 1977 to 8 in 1982; imports are about $US 1,250 million and exports $US 150 million.

(e) The organization of production: The technology situation

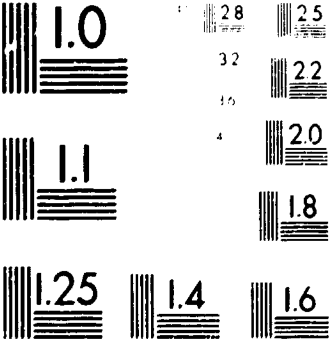
In India, one can see the particular importance of the Government enterprise BHEL, which has six plants and employs 70,000 persons. The output of BHEL covers the entire range of products, particularly, in the large equipment sector (boilers, turbines, alternators). Some important enterprises are listed in table 21.

In the Republic of Korea, a Government enterprise (KHIC), which employs 11,000 persons, is also engaged in the production of heavy equipment. The case study on this country gives information on the six most significant enterprises. They employ a total of 6,000 persons and have private Korean capital. Finally, table 22 indicates the range of products manufactured in the field of transmission and distribution, the national content and the origin of the technology.

These three countries make considerable use of foreign technology, mainly through licences with foreign companies that dominate the sector at world level. To some extent, this is a necessary transitional stage. Some transnational enterprises are established in Mexico and India, but it will be noted from the case study on Mexico that it is the subsidiaries of transnational enterprises that make the least contribution to the assimilation of technology.

Another factor must be discussed regarding the organization of production. It refers to the importance of workshops for foundry, forge and heavy mechanical engineering, for the purpose of making progress in mastering the sector, particularly as regards its heavy nucleus.

85.05.16
AD.86.07



MICROCOPY RESOLUTION TEST CHART

NATIONAL BUREAU OF STANDARDS

STANDARD REFERENCE MATERIAL 1010a

(ANSI and ISO TEST CHART No. 2)

Table 21. India: Electric power equipment industry

Products	History	Production	Enterprises	Technology
Equipment for power production	Up to the end of the 5th Plan (1961-66) all equipment was imported During the 1969-74 Plan, the local content rose to 25% During the 1974-79 Plan, the local content rose to 83% During the 1980-85 Plan, the local content will be 95-100%			
Boilers, turbines and alternators		Up to 31.3.83, BHEL produced 136 30-210 MW boilers - 500 MW boilers are planned for 1985-1986	BHEL (Public)	Originally USSR and Czechoslovakia, later KWU (FRG) and Combustion Eng.
Water turbines		Boilers from 2 MW to 165 MW	ABL (priv.) BHEL	Babcock Willcox USSR, UK, later Japan and France
Micro power	BHEL had identified a need for 519 installations from 0.5 to 2 kW		BHEL Jyoti (priv.)	
Transformers	National capacity up to 400 kV	Total capacity 34,500 MVA	32	GECLUK - Hitachi
High voltage circuit-breakers	SF6 circuit breakers preferred for high voltages	Capacity for 23,000 u	22	ASEA, Siemens GEC
Power capacitors			12	GE, GEC
Insulators	The necessary parts for 220 and 400 kV transformers are not produced		6	NGK (Japan)
Electric motors		Capacity for 7, 9 x 10^6 metric hp Production is of 5 x 10^6 metric hp	26	No further foreign technology
Pylons		90,000 t capacity		
Control equipment		Thyristors	9	Siemens

Table 22. Republic of Korea: Products manufactured

Equipment	Size	Local manufacturer	Local content as of 1983 (per cent)	Source of technology
Transmission				
1. Transmission accessories	345 kV	IL JIN	77.6	
2. Transmission line	A.C.S.R. 480 kV	KUK. JAE and many others	100	
3. Oil filled cable	154 kV 2000 class	Dee - Han	100	Sumitomo (Japan)
4. CV (Cross linked Polyethelene insulated and vinyl sheated) Power cable	154 kV	Keum-Sung	100	Hitachi (Japan)
5. Suspension insulators	10" class	Shin Han Ko Ryoe	100	Doulton (UK) Joslyn (USA)
6. Tower	345 kV Class	Hyun Dai & many others	100	
Sub-station				
1. Gas insulated switchgear	345 kV class	Hyo Sung Heavy Ind. Co. Ltd.	49.97	Hitachi (Japan)
	154 kV class	As above	0.7	As above
2. Gas circuit-breaker	345 kV class	As above	33.4	As above
3. Disconnecting switch	345 kV class	As above	82.8	Merin Gerlin (France)
	154 kV class	As above	83	As above
4. Transformer	345 kV class	As above	70	Westinghouse (USA)
	154 kV class	As above	70	As above
Distribution				
1. Recloser	27 kV class	IL JIN	25.[illegible]	
2. Sectionalizer	27 kV class	IL JIN	100	
3. Cut out switch	25 kV class	San Keung IL JIN JONG WON	100	
4. Lighting arrestors	18 kV class	Shin A IL JIN	71.[illegible]2	OTCWA (Japan) Legran Edisor Co (USA)
5. C.V. cable	22 kV Class	Dae Sung and many others	100	
6. Line Post insulators		Wan Yang and many others	100	
7. Suspension	7 1/2 class	Shin Han Ko Pyoe	100	Doulton (UK) Joslyn (USA)
8. A.C. Load interrupter Air switch	27 kV class	Shin - A and many others	77.[illegible]	Togali (Japan) S.C (USA)

In India, existing capacity is inadequate for providing castings of more than 20 tons. Future installations are envisaged for the production of large turbines and alternators (KWU licence).

In Mexico, a high-capacity foundry and forge are to be established (Japanese licence) to produce castings of 70-100 tons; a 4,500-ton press is also to be installed. These investments should make possible the production of 350 MW alternators and turbines.

In the Republic of Korea, it seems that investments have been made recently at Changwon, so that all important castings and forgings can be produced.

Whether they are based on the national market (India, China, Brazil, Mexico) or on an industrial development strategy that is more export-oriented (Republic of Korea, Singapore), the development of the electric power equipment sector in the semi-industrialized countries has been carried out with large-scale Government intervention, either directly through enterprises with public capital or indirectly by means of constant guidance and control being exercised over national or foreign private enterprises.

From the point of view of firms originating in the industrialized countries, the newly industrializing countries are often regarded as a threat: a close threat in the case of countries such as the Republic of Korea and a more distant threat in the case of countries such as India or China. Hence there can be no question of defining a development strategy for the electric power equipment sector in the case of this group of countries. Each of them formulates its own strategy including the aspect of bargaining power for acquisition of the technologies that they lack.

4. SYNOPSIS

The salient points of the strategies for each group of countries are indicated in the following tables.

In tables 23, 24 and 25 for each group of countries the characteristics of the group, the constraints and objectives with regard to consultancy and engineering services, assembly and engineering, maintenance of installations and equipment are shown.

Table 26 covers the implementation of strategies, emphasis being placed on the principal agents, relations with the capital goods industry, technological policy and training and co-operation needs.

Table 23. Characteristics, constraints and objectives

Small countries: Population less than 5 million

	Characteristics	Constraints	OBJECTIVES: Consultancy Services	OBJECTIVES: Assembly & civil engineering	OBJECTIVES: Maintenance of installations	OBJECTIVES: Equipment
Group 1 11 countries Very small market Capital goods industry almost non-existent (crafts)	E = 100 kWh/yr G = 100 - 200 GWh Predominantly rural population 300 - 1000 workers in the engineering industry and craft type blacksmiths	Financing of electrification programmes Very small market Embryonic mastery of technology	Developing national consultancy bureau in order to: 1) Define medium & long-term energy programme 2) Carry out feasibility studies and follow-up of projects	National priority in order to save foreign exchange	National priority in order to: 1) Increase the utilization rate of installations 2) Train personnel & improve apprenticeship effects	Very limited opportunities for equipment. However, development of activities related to low voltage cables, manufacture of consoles & swithboards, and poles for low & medium voltage distribution
Group 2 9 countries Medium-sized market Limited capital goods industry	E = 500 kWh/yr G = 200 - 400 GWh Large urban population 1000 - 3000 workers in the engineering industry	Domestic market is limited despite the possibilities for implementation of electrification	The objective for these countries is to achieve mastery of consultancy activities as soon as possible	Complete mastery of civil engineerring and assembly activities	Complete mastery	Some opportunities for certain countries: - Cables - Medium and low voltage gear Continuous development of activities related to low and medium voltage cables

E = Per capita electricity production.
G = Total electricity production.

Table 24. Characteristics, constraints and objectives

Medium-sized countries: Population between 5 and 20 million

	Characteristics	Constraints	OBJECTIVES: Consultancy services	Assembly & civil engineering	Maintenence of installations	Equipment
Group 3 20 countries Small market Low capacity for capital goods	E = 500 KWh/yr G = 1000 - 2000 GWh Manufacturing industry 5-10% of the GNP 3000-5000 workers in the engineering industry	Financing of electrification programmes and the equipment industry Limited market Manpower skills	Developing forecasting and feasibility studies Supervising assembly work	Carrying out civil engineering studies and work	Total mastery and production of spare parts. Repair of certain types of equipment (e.g. transformers)	Some countries will be able to produce medium voltage gear and equipment (transformers, isolating switches)
Group 4 13 countries Medium-sized market Medium capacity for capital	E = 500 kWh/yr G = 3000 - 5000 GWh Manufacturing industry 10-15% of GDP. Production of electric power equipment in some countries: motors transformers, cables, etc.	Market very close to the economic limits (search for regional partners) Limited negotiation capacity for the purchase of technology	Development of engineering activities in order to increase negotiation capacity It could be considered that consultancy activities are mastered in the majority of these countries	Most of the countries have already acquired a great capacity for mastery in these sectors. However, production of spare parts on a larger scale should be taken as an opportunity to train skilled and specialist workers.		Several objectives should be pursued: - Low and medium voltage cables Medium voltage gear - Commencement of production of simple equipment for power stations (metal structures, boiler-making work)

E = Per capita electricity production.
G = Total electricity production.

Table 25. Characteristics, constraints and objectives

Large countries: Population above 20 million

	Characteristics	Constraints	OBJECTIVES	
			Consultancy and engineering services	Equipment
Group 5 4 countries with medium-sized markets and limited capital goods industry	See the objectives for the medium-sized countries (Groups 3 and 4)			
Group 6 15 countries	G= 10,000 - 20,000 GWh Manufacturing industry 15% - 20% of GNP	Very high cost of industrial investments	1. Total mastery of project engineering activities (technology unpackaging)	Commencement of production of high and very high voltage equipment and gear
Large market Electric power equipment industry fairly well developed	Production of electric power equipment - Low and medium voltage equipment - Commencement of high voltage equipment production - No power station equipment, or only little	High technological complexity of the equipment. Lack of planning of the capital goods sector Need for very highly skilled staff	2. Commencement of R&D activities 3. Definition of a technology import policy	Development of the production of equipment (subassemblies) for power stations (boilers,piping,etc) For some countries commencement of the production of very complex equipment (turbine components)
Group 7 7 countries Very large market Highly developed capital goods industry	NICs	Very high cost of investments Market for heavy equipment very close to the economic limits Very high technological complexity	1. Mastery of process engineering 2. Development of R&D activities 3. National system for patents and licences	- Strengthening of industrial capacity in the fields of: High and very high voltage equipment and gear Equipment of very high complexity

G = Total electricity production.

- . -

Table 26. Implementation of strategies

	The principal agents	Linkage with the capital goods industry	Training and technological policy	Co operation needs
Small countries Group 1	1) State company for the generation, transmission and distribution of electric power	1) Multipurpose engineering maintenance workshop that can be used for other sectors	- Sepecialized training in maintenance	Sepecialized technical assistance for training in the operation & maintenance of the installations
Group 2	2) National services for planning and project studies 3) Civil engineering and assembly enterprises	2) Multipurpose sheet metal and general metal working shops for the production of metal cabinets and boxes as well as metal furniture and equipment for renewable energy sources	Training for energy planning studies	Specialized technical assistance for the development of national consultancy services
Medium-sized countries Group 3	1) The Government, to: implement financing - promote specific training - Negotiate technical assistance 2) Civil engineering enterprise 3) Electric cables enterprise.	1) Multipurpose metal structures and boiler-making workshops (pylons, tanks) 2) Multipurpose sheet metal and general metal working shop	- Specialized training in electrical trades Specialized training for project studies Policy for the search for partners for technical assistance	- Specialized technical assistance for training in electrical trades
Medium-sized countries Group 4	1) The Government - programming of public purchases - temporary protection of the infant industry - definition of technological policy 2) National engineering companies 3) National industrial enterprises 4) Enterprises in the developed countries and NICs	1) Development of the infrastructure (foundry, forging, machining) 2) Development of specialized subcontracting (heat treatment surface coatings)	- To develop negotiation capacity - To select the technologies to be imported Technological unpackaging	- Acquisition of technology abroad for the development of a national electric power equipment industry Partners: Enterprises in the NICs
Large countries Group 6	1) The Government Promotion of national engineering capability - Promotion of a capital goods industry - Programming of public purchases 2) National engineering companies 3) Industrial enterprises 4) Transnational corporations	- Iron and steel - metallurgy - Heavy infrastructure Subcontracting	R & D centre Plan for the development of a capital goods industry Policy for the acquisition of technology	Small and medium scale enterprises in the developed countries Transnational corporations

5. CONCLUDING REMARKS

The present economic situation and the development prospects of a least developed country or a newly industrializing country are very different. Taking into account the diversity of the real situations within the developing countries, each country could specify a more or less unique strategy, both at the domestic level and at the level of bilateral, multilateral and global negotiations. In the present paper, a typology has been proposed, a classification of developing countries in different groups has been made, that should make it possible to prepare concrete strategies for commencing or developing production in the sector concerned: electric power equipment. This typology leads to orientations regarding a deliberate development policy in this sector for each of the seven groups studied.

The capital goods sector, of which electric power equipment constitutes an important part, is the key industrial sector for national industrial integration. Taking into account the advantages and constraints of the countries in each group, the production of electric power equipment could be based on:

(a) A national political decision clearly stated and concretely implemented;

(b) The recognition of the leading role of national software activities (studies, engineering);

(c) The improvement of the bargaining situation vis-à-vis the suppliers of technology.

Finally, particularly in the case of the small- or medium-sized countries, it should be noted that the search for regional co-operation agreements (between several countries) would make it possible to attain the critical size for markets for many products more rapidly. However, so far very few examples of industrial planning covering several countries have yet taken concrete shape. Thus, the emphasis in this paper is mainly on national strategies.

For the guidance of our publications programme in order to assist in our publication activities, we would appreciate your completing the questionnaire below and returning it to UNIDO, Division for Industrial Studies, P.O. Box 300, A-1400 Vienna, Austria

---

QUESTIONNAIRE

Electric power equipment production in developing countries: A typology and elements of strategy

	(please check appropriate box) yes	no
(1) Were the data contained in the study useful?	/_7	/_7
(2) Was the analysis sound?	/_7	/_7
(3) Was the information provided new?	/_7	/_7
(4) Did you agree with the conclusion?	/_7	/_7
(5) Did you find the recommendations sound?	/_7	/_7
(6) Were the format and style easy to read?	/_7	/_7
(7) Do you wish to be put on our documents mailing list?	/_7 If yes, please specify subjects of interest	/_7
(8) Do you wish to receive the latest list of documents prepared by the Division for Industrial Studies?	/_7	/_7

(9) Any other comments?

Name:
(in capitals) ....

Institution:
(please give full adress) ....

Date: ....