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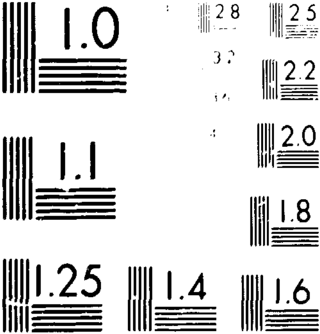

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STRATEGIES FOR ENTRY INTO THE PRODUCTION OF CAPITAL GOODS FOR ELECTRICAL ENERGY

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I - POSSIBLE ROUTES FOR ENTRY INTO THE CONSTRUCTION OF CAPITAL GOODS FOR THE PRODUCTION AND DISTRIBUTION OF ELECTRICAL ENERGY

1.1. The general organization of the capital goods sector for electrical energy

The construction of capital goods for the production and distribution of electrical energy covers several technological components which may be ranked in the following order of relative importance:

- the operation of installations

- the maintenance and repair of capital goods

- engineering

- the manufacture of capital goods

- research and development.

It is found that, to this ranking of the various components involved in the construction and installation of capital goods, there also corresponds a ranking of the various countries: the most industrialized countries master all the technological components, whereas the less developed countries master only certain elements. It is possible, as an initial approach, to establish a ranking of the levels of technological independence of the countries in regard to capital goods for electrical energy; these can be indicated as follows:

- level 0 includes those countries which can only carry out part of the technology for operating the installations themselves, such countries signing agreements for technical assistance with foreign countries for the purpose of mastering the operation of their installations.

- level 1 includes those countries which master the technologies of operating the installations, carry out part of the maintenance and repair (routine repair and certain large repairs), produce certain parts for imported equipment, and also carry out preliminary studies.

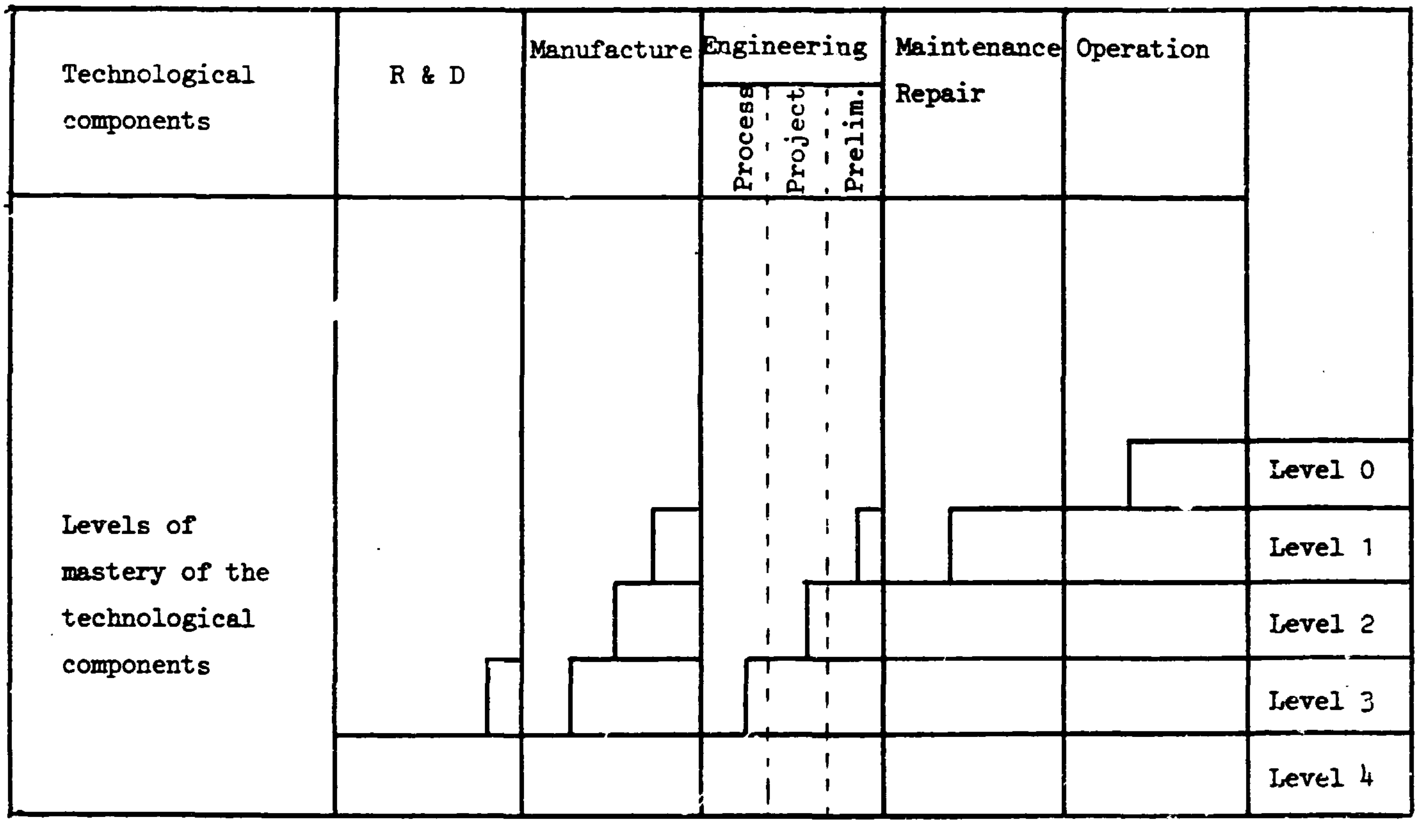
- level 2 includes those countries which master the majority of the maintenance and repair tasks, carry out all or part of the project engineering, and manufacture some sub-assemblies of the capital goods.

- level 3 includes those countries which master a large part of the process engineering and a major part of the manufacture of capital goods, and which are also involved in research and development activities.

- level 4 includes those countries which master all the process engineering, manufacture the whole extended range of capital goods and integrate the design, research and development of these capital goods at the highest level. At this level all the technological components are mastered.

It is possible to represent each of these levels in the following diagram:

LEVELS OF INDEPENDENCE OF COUNTRIES IN THE FIELD OF CAPITAL GOODS FOR ELECTRICAL ENERGY



1.2. A study of the principal technological components and of the conditions for entry

In the following pages we will be examining the content of the principal technological components necessary for producing installations for electrical energy, that is to say engineering, manufacture and R & D.

In fact it does not seem to us to be necessary to study the conditions for technological mastery of "operation" and "maintenance and repair" which constitute the principal components of levels 0 and 1; these components concern the operation and maintenance of installations rather than the actual production of capital goods, and also most of the developing countries can master the operation and part of the maintenance and repair of their installations. It should, however, be pointed out that the conditions for mastery pass through technical assistance given to the user of the installations by the supplier of the equipment.

1.2.1. Engineering in the capital goods sector for electrical energy

It is possible to distinguish three principal levels which can be successively mastered by the developing countries:

- level 1, preliminary studies

This covers, amongst other things, the analysis of the supply and demand for electrical energy, the additional generating capability to be installed, the choice of the technologies used in the power stations - for example the choice between gas or steam turbines - the additional distribution network to be implemented (power and distribution networks), and also covers problems of standardization.

Mastery of preliminary studies presupposes a high level of technical potential, including engineers and economists capable of directing and controlling the work of foreign study companies intervening at level 2 (project engineering). This study structure should allow the country to take over fully its rôle as final owner in the design and construction of the installation.

- level 2, project engineering

This covers the total design of a project, studies on the central and peripheral parts of the projects, etc. Mastery of this level by the developing countries allows them to assume the rôle of principal contractor for projects. Most of the developing countries do not have their own services for mastering this level, and the growth of the formula of turnkey contracts does not favour the creation of local engineering capabilities. De-grouping of the projects, as carried out by certain countries, is a way of creating local capabilities in this respect; this formula provides a possibility for local participation at a technical level (basic technical studies initially, part of the detailed technical studies subsequently). Technical assistance or advice from foreign engineering consultancy companies, covering the whole of the project or components in the project, according to the complexity and dimensions of the installations, makes it possible for the countries to acquire progressive mastery of the projects. It should however be noted that the intervention of external consultants (consultant engineers or engineering companies) should only be of a technical character, management of the whole of the project remaining in the hands of the principal contractor.

Mastery of project engineering by the developing countries constitutes an effective means for incorporating locally manufactured equipment in the building of installations for electrical energy. As long as project engineering studies are carried out by foreign companies the latter will tend to minimize the possibilities for local manufacture of equipment; most of the time the fact that the foreign engineering companies are related to suppliers of capital goods contributes towards minimizing such possibilities.

- level 3, process engineering

One of the design tasks which it is most difficult to carry out concerns process engineering. "The rôle of process engineering is to draw up the flow-sheet which gives the layout of the production unit with the principal characteristics of the items of equipment. The flow-sheet for a given production unit is the optimization of the process as a function of the expected characteristics of the final product, the characteristics of the inputs, and other factors intervening in production"(1). This level necessitates in-depth knowledge of the design of capital goods; close relationships with the manufacturers of capital goods are necessary at this stage in the field of studies on design, manufacturing methods and production.

For each of these levels the public organizations which produce and distribute electrical energy have an essential rôle to play in creating and promoting local engineering capabilities. We can give, as one example amongst others, the rôle of Electrobras in Brazil in the development of a local capability for the design and construction of power stations: the rôle of Electrobras is shown in:

- the development of local consultancy services for drawing up pre-feasibility and feasibility studies

- the development of local engineering capabilities for defining the project and for carrying out the peripheral parts of the project or the whole of the project. At the present time there are a number of engineering companies including:

  . MORRISON KNUDSEN INTERNACIONAL DE ENGENHARIA S.A. (projects for the Furnas, Estreito, Porto Colombia and Itaipu power stations).

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(1) Transfer of Technology and Engineering in the Capital Goods Industry - IREP - February 1980.

. HIDROSERVICE - Engenharia de Projetos Ltda
(project for the Sobrabrinho power station).

. ENGEVIX S.A. - Estudos e Projetos de Engenharia
(project for the Tucuri power station and for the Itaipu lateral dam).

. THEMAG ENGENHARIA
(project for the Itaipu transmission network.

. MILDER KAISER ENGENHARIA S.A.

. PROMON ENGENHARIA S.A.

. MONTREAL ENGENHARIA S.A.

- the incorporation of equipment manufactured locally; whereas a few years ago less than half of the value of the equipment for hydroelectric power stations was produced locally it was decided in 1978, for the construction of the Itaipu power station, that 81% of the value of the hydraulic turbines (with a unit power of 700 MW) and 86% of the value of the alternators would be manufactured in Brazil. This decision forced the foreign companies participating in this project to develop execution study capabilities in Brazil, to establish certain production capacities (particularly in forging and casting), and to contribute to the training of engineers and technicians in the design and methods offices, and of the workers, both in the subsidiaries of the companies established in Brazil and also in the local companies involved in the production of this equipment.

1.2.2. The manufacture of capital goods for electrical energy

The implementation of production capacities in the field of capital goods for electrical energy can only be carried out progressively by the developing countries. In fact the material, technical and human resources which are necessary are considerable, making it necessary to proceed by the successive mastery of levels of manufacture.

Generally speaking the manufacture of capital goods for electrical energy involves four technological production routes, the increasing complexity of which (in regard to the skills required from the labour, the methods of organizing production, the methods of manufacture, and the means of production) correspond to four levels of technological independence. These levels are as follows:

- level 1, mastery of the route: "structural metalwork - sheet metal working - general boilerwork"*

- level 2, mastery of the route: "heavy boilerwork - welding - machining"

- level 3, mastery of the route: "casting - forging - heavy machining"

- level 4, mastery of the route: "precision engineering - instrumentation".

What are the conditions for technological independence and access specific to each of these levels ?

- Level 1 - covering "structural metalwork - sheet metal working - simple boilerwork", does not require major industrial resources, the required production means including equipment for bending sheets and plate, stamping, cutting and manual welding.

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* "boilerwork" or "metal fabrication"

Since it does not involve highly technical parts quality control is less important. Production can be carried out from execution drawings supplied by an outside company. No particular competence is necessary, and even an artisan could produce the sub-assemblies belonging to this route. The necessary skills concern essentially welders, boilerworkers and sheet metalworkers, the training of which can be carried out in six months in the developing countries. Mastery of this route by these countries requires three to five years to assimilate the production techniques fully.

- Level 2 - covers the manufacture of large welded parts, so production resources have to be considerable, particularly the existence of efficient boilermaking plant with heavy lifting and welding facilities (automatic welding), heavy mechanical resources (machining), and finally the welded parts require very strict quality control. At this level manufacturing methods are important, and the country must itself provide these; a methods office is therefore necessary, and in addition to this a design unit for parts must be established locally to carry out a small part of the execution drawings for the parts being manufactured. The production personnel required consists essentially of engineers, the training of which takes a relatively long period (three to five years). The time for the assimilation of this route is relatively variable, depending on the industrial level which has been achieved in other fields by the country, since some industrial infrastructure is in fact required when mastering the "heavy boilerwork" route.

- Level 3 - covering "casting - forging - heavy machining" necessitates, on the part of the country which seeks to master the route, a basic metallurgical industry. The casting and forging resources which are needed for the manufacture of certain sub-assemblies of capital goods for electrical energy are considerable. This route covers the strategic components of capital goods for electrical energy (hydraulic turbine wheel, turbo-alternator rotor shaft, etc.) and their manufacture necessitates labour having competence in regard to engineering but also in the field of hydraulics (for the manufacture of hydraulic turbines), of thermodynamics and the strengths of materials (for the manufacture of certain boiler sub-assemblies), of aerodynamics (for the manufacture of turbo-alternators), of combustion (for thermal turbines), of refrigeration and fluid circulation (for transformers), etc. With this mastery of engineering and metallurgy are also associated various techniques having implications in the design and manufacture of capital goods. The design of the production ranges, the ranges of tools, the supervision of work while it is being carried out and quality control on parts, etc., are of major importance in the organization of the work. A highly structured methods office is necessary; study capabilities, able to provide all the execution drawings, are also necessary. Cooperation in the field of the design and manufacture between the country and the companies holding the technological know-how is therefore essential at this stage. This cooperation implies close communication at all levels (design offices, methods offices, workshops and quality control). The period required for the assimilation of the techniques at this stage varies, depending both on the nature of the cooperation and of the industrial environment of the country.

- Level 4 covers the manufacture of certain highly complex and strategic sub-assemblies which call on very special technologies (precision engineering, automation based on electronics, etc.). These are parts or sub-assemblies of the highest responsibility (in particular the bearings and positioning parts for hydraulic turbines, failure of which can result in damage to the whole turbine) and of high technical content (precision engineering of the order of 0.1 to 0.01 mm), requiring highly skilled labour, very accurate machines, considerable know-how in regard to special techniques and highly complex tests.

Designs and studies have a special place in this route, also, at production level: manufacturing methods, tooling, test and quality control methods are particularly important. This route is integrated at the level of the major companies in the industrialized countries, and any desire to master this route by the developing countries must involve cooperation in the field of research and development and in design studies.

In total, therefore, entry into the manufacture of capital goods for electrical energy by the developing countries can be effected progressively by the successive mastery of the technological production routes. The increasing complexity of these routes, from level 1 to level 4, necessitates at the same time:

- increasing specialization of the production apparatus and techniques

What characterizes routes of levels 1 and 2 is a certain multi-purpose character of the production apparatus and of the production techniques: the production techniques cover heavy engineering, and using the production apparatus involved in these two routes other sub-assemblies of capital goods used in other sectors can be manufactured, such as welded sub-assemblies for the iron and steel industry, for petrochemicals, etc.

At level 3, although the production apparatus still remains multi-purpose, the techniques used (hydraulics, thermodynamics, etc.) necessitate special technological know-how on the part of the labour force, and from this there results a work organization which is specific to the manufacture of capital goods for electrical energy.

At level 4 the techniques utilized and the production apparatus are highly specialized.

- <u>increasing production organization capabilities</u>
  Scarcely developed in the first two levels the methods of production, the design of production ranges, of ranges of tools, of supervision during production, of quality control of parts and of technical tests become of importance in the last two levels. Passing from level 1 to level 4 necessitates the progressive mastery of the organization of production by the development of departments such as supplies, launching and progressing of work, planning of production, tooling, quality control and testing, etc.

- <u>progressive mastery study capabilities</u>
  Entry into the production of capital goods for electrical energy at level 1 does not necessitate any special study capabilities, so production can be carried out on the basis of detailed studies provided by a foreign company; passing to the other levels necessitates the development of study capabilities so as to design, overall and in a detailed manner, the products which are to be manufactured, to make adaptations on the products as a function of new components and

sub-assemblies, of new needs on the part of the clientele, of minimization of production costs, etc.

1.2.3. Research and development (R & D) in the field of capital goods for electrical energy

The function of R & D is not to undertake fundamental research but to utilize the results of scientific research so as to:

- define new products. In this field R & D involves, inter alia, super-conductivity for increasing the unit powers of equipment and also calls on highly developed technologies such as strengths of materials, cryogenics, etc.

- determine new methods of production. This function is very important in the capital goods sector for electrical energy, in particular, so as to reduce production costs by the use of new materials or new manufacturing processes. From this follows the interdependence of the results of R & D with the actual production of the capital goods: the results of R & D induce modifications in the design of the capital goods, which themselves determine new methods of manufacture of these goods. The close relationships which exist between R & D, design studies and manufacturing methods explain the difficulty which the developing countries have in mastering the production of capital goods if efforts are not simultaneously undertaken to develop some R & D capabilities.

R & D work necessitates financial and material resources (test laboratories, construction of prototypes, etc.) and human resources (engineers, technicians and workers having acquired a high level of experience) which only some major firms of world standing in the sector are capable of implementing. Cooperation agreements (usually included in licensing agreements) make it possible to some firms to benefit from the results of R & D carried out by the major firms (in France, for example, the licensing agreements signed between Jeumont-Schneider and the American Westinghouse company have allowed Jeumont-Schneider to benefit from the results of the R & D carried out in regard to certain capital goods).

Mastery of R & D necessitates, for the developing countries, considerable effort, and also involves technical cooperation with the major firms in the sector. Very few developing countries have already reached a sufficient technological level to develop an R & D structure in the sector of capital goods for electrical energy. Amongst the countries which have achieved this level are India with the Indian B.H.E.L. (Bharat Heavy Electrical Ltd.) company which devotes 3 to 3.5% of its turnover to R & D. This company is autonomous technologically for the development of small power stations, for high power equipment (steam turbines and generators of 1000 MW) and a collaboration agreement has been signed with the German KWU company with a view to mastering the design and production of this type of equipment.

CONCLUSION

Entry of the developing countries into the production of capital goods for electrical energy passes through the progressive mastery of the three major components which are engineering, manufacture and R & D.

It may be assumed that a first stage consists of mastering preliminary studies and the manufacture of sub-assemblies involving the structural steelwork and general boilerwork route.

A second stage consists in integrating general engineering and the heavy boilerwork - welding - machining route.

Beyond these two levels the transfer of technology comes up against a "hard core", in respect of which technological independence is more difficult to achieve. The components of this "hard core" are the manufacture of certain highly complex and strategic sub-assemblies which call on very special techniques and, in certain cases, require considerable know-how, the process engineering activity necessitating mastery of the design of capital goods, the R & D activity and the design activities associated with the production of all the equipment. At this level there are interrelations between the three technological components: the design of equipment and, in the last resort, the manufacturing methods and the manufacture itself are closely linked with R & D. This calls on very diverse and complex technologies and involves, if a level of technological independence is to be achieved, devoting financial, technical and human resources which only some firms of world-wide importance are capable of implementing

Penetration by the developing countries into this "hard core" is through technical cooperation with the major firms; this cooperation becomes even more difficult to implement since mastery of this "hard core" constitutes one of the means for the major companies to safeguard their position in international competition, hence their reluctance to transfer this part.

II - THE BARRIERS TO ENTRY ERECTED BY THE MAJOR FIRMS OF THE SECTOR: THE CASE OF BRAZIL

In order to organize international trading in electrical equipment (in regard to price, competition, etc.), and in order to prevent the appearance of new producers on the international scene, the major firms manufacturing electromechanical equipment have signed agreements between themselves so that a powerful cartel of producers has been formed on an international scale.

The existence of this cartel may make entry into the production of capital goods for electrical energy by the developing countries very difficult. The case of Brazil illustrates the barriers erected by firms in the development of a sector for capital goods for electrical energy.

The emergence of an electrical equipment sector in Brazil goes back to the fifties when several companies with Brazilian capital began to manufacture equipment for the production and distribution of electricity. At the same time the policy of stimulating investments by the Government, and the prospect of a vast market, attracted foreign capital; in the sixties there were about ten subsidiaries of multinationals.

During the seventies a large number of these Brazilian companies were absorbed by foreign investors. An UNCTAD report(1) illustrates how domination and control of the Brazilian industry for electrical equipment was achieved by foreign interests.

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(1) Impact on developing countries of restrictive business practices of transnational corporations in the electrical equipment industry: a case study of Brazil. Study prepared by B. EPSTEIN and K.R.U. MIROW, UNCTAD/ST/MD/9.

Generally speaking it seems that, in Brazil, the multinationals formed a national cartel through the Brazilian Research Institute for the Development of Exports of Heavy Electrical Equipment (IBEMEP), had recourse to the control of materials and components used in manufacture, and also used the import and concession regulations to weaken local companies and to take control of them.

- <u>control of materials and components used in manufacture</u>

Independent manufacturers who undertake production in the developing countries are not of sufficient size to justify the creation of divisions specializing in certain components, nor do they have any great power in respect of their suppliers. These companies depend therefore on the members of the cartel and their subsidiaries, from which they must obtain ancillary and test apparatus together with certain supplies and components. One of the principal weapons used by the International Electrical Association (IEA) is, consequently, control over the materials and components needed by independent producers. Certain facts make it possible to believe that in Brazil this weapon was used to weaken the local companies in two ways, either by completely denuding the market of certain manufacturing components or by making the supply of materials dangerously unstable. The authors of the UNCTAD report cite certain examples which tend to prove that control of materials and test equipment by the multinationals made the situation of certain Brazilian companies precarious and so facilitated their purchase by foreign companies established in Brazil.

- <u>control of the Brazilian market by means of import regulations</u>

The UNCTAD study shows how the multinationals used import regulations to their own advantage and so contributed to the replacement of domestic production by imports and hence to a reduction in the technological level:

"In the early 1960's hydroplant was built in Brazil. Brown Boveri built two 59 MVA hydrogenerators for the Peixoto Power Plant. Bardella S.A., an independent Brazilian company, built hydroturbines under a technical licence from Voith. Most hydroplant, however, was imported. The Brazilian subsidiaries of firms such as General Electric and Siemens produced locally less than 30% of hydroplant to be installed in Brazil. They made parts that are heavy and difficult to transport while the home market plants were responsible for the high value, high technology hydroplant components."

"The problem in Brazil was not lack of capacity. According to one report(1) the Brazilian factories were utilizing about 50% of capacity during this period. Nor was technology the problem. Bardella S.A.

(1) Banco Nacional do Desenvolvimento Economico (B.N.D.E.). Associação Brasileira Para o Desenvolvimento das Industrias de Base (ABDIB) et Instituto de Planéjamento Economico e Social. (IPEA) setor de Produção de Bens de capital Sob Encomenda Sintesa da Pesquisa. Cited in the UNCTAD study.

had built hydroturbines in Brazil under Voith licence. General Electric and Siemens made technological know-how available to their Brazilian subsidiaries. And in 1975, General Electric stated that it had the capacity and technology in its Brazilian plant to produce at least 80% of the components of hydroturbines and generators up to 800 MW."

"To understand the lack of hydroelectric equipment production, one must look further. In 1964 Voith opened up its own plant in Brazil for hydroturbines. Since it would be competing with Bardella, Voith withdrew its technical licence from Bardella S.A. (In 1973, Bardella signed a license agreement with AB Nohab of Sweden). During this same period, the early 1960's, Siemens built a plant in the Federal Republic of Germany, for hydroelectric generators. There is, however, no domestic demand in that country for such equipment and little demand in other European countries. Siemens, as well as other manufacturers of hydroelectric equipment, had to depend on third-world countries for orders. For this reason one might question whether the withdrawal from Bardella of a technical licence for hydroturbines by Voith did not reflect IEA pressure to eliminate production of a similar local product in the Brazilian market."

"In 1964, subsidiaries of transnational corporations requested and received permission to import hydroelectric plant of a size that previously had been produced in Brazil. During the subsequent years, 1965-1975, nearly two-thirds of the 18,363 MVA of hydroelectric plant installed in Brazil was imported. This is an example of transnational corporations importing when the product could have been procured locally if Bardella had been allowed to develop its potential."

In total the multinationals established in Brazil had a negative impact on the development of the heavy electrical equipment sector. Their restrictive practices resulted in weakening the Brazilian companies; as a consequence the trading balance of Brazil fell heavily into deficit in regard to electrical equipment, with imports of electrical equipment(1) increasing from $74.5 million in 1964 to $533.4 million in 1974, an increase of 616%(2). In 1974 imports of electrical and electronic equipment by the 35 multinationals exercising their activities in Brazil represented half of their total sales in Brazil; at the same time local production installations for the same imported equipment were operating at 52% of their capacity.

(1) All items SITC 711, 722, 723, 725 and 731, also including equipment for the production and distribution of electrical energy, domestic electrical appliances, and railway rolling stock.

(2) UNCTAD report cited above: UNCTAD/ST/MD/9.

III - SOME EXPERIENCES IN REGARD TO ENTRY INTO THE PRODUCTION OF CAPITAL GOODS FOR ELECTRICAL ENERGY

At the present time some of the developing countries, including India, Brazil, South Korea, Mexico, Colombia, Indonesia and Algeria, have established production capacities for equipment for the production and distribution of electrical energy. Not all these have reached the same level of production; India seems to have achieved some technological independence and its diversified production covers most of the heavy equipment for the production and distribution of energy, whereas other countries such as Colombia are producing mainly high voltage transformers and certain items of power station equipment such as boilers and condensers.

1 - INDIA

In the case of India the rôle and place occupied by the public company Bharat Heavy Electrical Ltd., (BHEL) has certainly contributed towards favouring the development of the sector for electrical equipment goods.

A study by the UNCTAD Secretariat(1) gives some idea of the motive rôle exercised by the Indian company in the development of the electrical equipment sector:

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(1) "Energy supplies for developing countries: Issues in transfer and development of technology."
Study by the UNCTAD Secretariat TD/B/C.6/31 - 17 October 1978.

"Created in 1955 this company relied in the initial years on the technical collaboration agreements with the United Kingdom, the Soviet Union and Czechoslovakia to train personnel and to obtain designs and machinery. In 1974 the company was reorganized with the aim of developing into a truly engineering firm. At the present time BHEL, with an annual capacity of 4,000 - 5,000 MW, is one of the top ten power equipment manufacturers in the world. They are currently devoting 3 to 3.5% of turnover to R & D and have signed a collaboration agreement with KWU in the Federal Republic of Germany to make large size steam turbines and generators ranging up to 1000 MW, and is presently engaged in the manufacture of its first 500 MW set. In all smaller ranges the company is self-sufficient. At the same time it has been instrumental in achieving the Indian objective of reducing to a minimum the imports of electrical equipment.

About 90 hydroelectric, 60 thermal and 4 nuclear power sets are in various stages of design, manufacture and erection in India. Nearly 80% of the 1720 MW added to the Indian installed capacity in 1974 - 1975 was contributed by BHEL and out of the planned addition in the Fifth Five Year Plan, 85% will be BHEL equipment."

At the present time India has arrived at a stage which allows it to be present on the international market; BHEL achieves 15% of its turnover abroad[1], its technical competence and the low cost of its labour[2] both in regard to design and manufacture gives this company the possibility of finding major outlets, particularly in the developing countries.

2 - MEXICO

The heavy electrical equipment sector in Mexico remains largely dependent on imports from abroad. Imports supply between 50% and 60% of the domestic demand for electrical equipment; recourse to imports is even greater in the equipment for producing electrical energy, local production meeting scarcely 20% of national needs.

The Mexican industry for electrical equipment comprises 45 firms of which about ten specialize in equipment for the production of electrical energy, some major firms having product lines which include several types of equipment. The majority of the companies are subsidiaries of multinationals (cf. Table 1).

(1) During the 1976-77 financial year the company received an order from Libya for the turnkey construction of a 2 x 120 MW power station, an order from New Zealand for the supply of hydraulic generators with a total power of 544 MW, and an order from Saudi Arabia for the Wadi-Jizou electrification project.

(2) Production costs are, on average, 10 - 15% lower than those of Japanese companies.

TABLE 1 - MEXICO

DOMESTIC MANUFACTURERS

Manufacturera Fairbanks Morse, S.A. (subsidiary of Fairbanks Morse, U.S.)

Generating equipment: single-phase AC, single-phase light plant, and three-phase generators; internal combustion plants for lighting; specialized generator sets. Transformers: dry type, distribution and lighting transformers, and autotransformers.

Sociedad Electro-Mecanica S.A. de C.V. (licensee of Electric Machinery/ Cleaver Brook, U.S.)

Generating equipment: Specialized generator sets, three-phase generators, and power boilers. Switchgear: power and control panels for generating plants; distribution, automatic alternate control, emergency plant control panels; circuit breakers, disconnecting knife switches; and high tension safety interrupters.

Kohler de Mexico, S.A. de C.V. (subsidiary of Kohler, U.S.)

Generating equipment: internal combustion plants for lighting, single-phase AC and single-phase light plant generators.

Miller de Mexico, S.A.

Generating equipment: light plant generators with internal combustion engines.

Inductomex, S.A.

Generating equipment: specialized motor generator sets.

Conductores Monterrey (licensee of McGraw Edison, U.S.)

Transformers: control, current and power; dephasing, rectifying, and specialized transformers; runway lighting; distribution and lighting transformers; underground lighting; variable autotransformers and cables.

Electrotecnica Balteau S.A.

Transformers: power, current, dephasing and specialized.

Industrias IEM, S.A. de C.V. (licensee of Westinghouse, U.S.)
Transformers: distribution and lighting, power, cooling, dry type distribution, dephasing, rectifying transformers for underground lighting and distribution, power transformers with forced air and oil cooling; and autotransformers. Switchgear: regulation and control systems, alternative automatic command panels, power and control panels for generator plants, high- and low-tension distribution panels, interrupters in oil, and electromagnetic interrupters.

General Electric de Mexico, S.A. (subsidiary of General Electric, U.S.)
Transformers: distribution and lighting, underground distribution and lighting, control, rectifying, dry type distribution, specialized, and power transformers with forced air and oil cooling. Switchgear: protection, control and measurement thermomagnetic interrupters; automatic command, distribution switchboards; power and control panels for generating plants; disconnecting knife, oil switches; and control relays.

Industria Sola Basic, S.A. (subsidiary of Sola Basic, U.S.)
Transformers: dry-type, control and rectifying, specialized, and autotransformers.

Cutler-Hammer Mexicana, S.A. (subsidiary of Cutler-Hammer, U.S.)
Switchgear: selective, thermomagnetic interrupters; emergency plant controls; knife switches; relievers; and control cabinets.

Balmec S.A. (licensee of General Electric, U.S.)
Switchgear: Capacity and control panels and power factor indicators.

Brown-Boveri Mexicana S.A. de C.V. (subsidiary of Brown-Boveri, Switzerland)
Switchgear: lighting and motor, emergency plant controls; automatic and non-automatic interrupters; power and control panels for generating plants; distribution, automatic control, capacitor-equipped panels; compressed air interrupters (high tension, thermal overcharge relievers; disconnecting knife switches; and bus-bars.

Square D de Mexico S.A. (subsidiary of Square D, U.S.)

Switchgear: automatic alternative commsnd panels; emergency plant controls; power and control panels for generating plants; automatic start-up control transference and stopping panels for emergency plants; knife switches; and disconnecting, thermomagnetic, multicontact, control and measurement selector interrupters.

Honeywell de Mexico, S.A. (licensee of Honeywell, U.S.)

Switchgear: all types of control panels.

Ce-Rrey (subsidiary of Combustion Engineering, U.S.)

Generating equipment: power boilers. Switchgear: all types of control panels.

Babcock and Wilcox de Mexico, S.A. (subsidiary of Babcock and Wilcox, U.K.)

Generating equipment: power boilers.

Clayton de Mexico, S.A.

Generating equipment: power boilers.

Metalver, S.A.

Generating equipment: power boilers.

Source: GMS Electrical Energy Systems. US Department of Commerce

Five companies produce steam boilers but two of these, (Ce-Rrey and Babcock and Wilcox de Mexico) supply more than 60% of the market; steam boiler components are imported, but highly specialized local companies provide most of the boiler components.

In the production of alternators, powers of 500 MW are produced locally; in this field the largest producer is Manufacturera Fairbanks Morse (subsidiary of Fairbanks Morse USA) which has 40% of the market; the other producers are Sociedad Electro Mecanica, Kohler and Miller which have 35% of the market. Nearly half of the components used in the production of alternators are imported.

Power and distribution transformers are supplied by about fifteen companies; IEM and Electrotecnica Balteau have 40% of the market; the other dominant firms are Conductores Monterry, General Electric de Mexico and Industrias Sola Basic. More than 95% of the components for transformers are produced in Mexico.

In switchgear about twenty companies produce this type of equipment, but no company dominates the market; the subsidiaries of three American firms (Square D, General Electric and Cutler Hammer) account for half the national production of switchgear, whilst the Mexican subsidiary BBC contributes approximately 20%.

Generally speaking Mexican production of all electrical equipment remains dependent on foreign technology. Between 1970 and 1977

12 technological agreements were signed to make equipment for electricity generation or distribution. 75% of them were made between parent companies and their Mexican subsidiaries and 88% of the payments can be attributed to them. Royalty payments, generally calculated as a percentage of sales, amounted to about US$ 500,000 per year over the period 1970-1977[1].

The Mexican electrical equipment industry has not reached the level of development of that of Brazil, but nevertheless certain analogies can be seen in the relatively important position of the subsidiaries of the multinationals in each type of equipment. A large part of local production can be attributed to them; however private Mexican firms exist in this sector, most manufacturing under foreign licence. The principal preoccupation of the Government is to encourage the production of electrical equipment in Mexico, the establishment of mixed companies for 400 MW transformers, formed from multinationals, private Mexican financial companies and the Nacional Financiera, in order to favour the national industry and the creation of jobs; however it is still not known how the transfer of technology to the Mexican associates will be carried out.

(1) UNCTAD op. cit. TB/B/C.6/31.

3 - SOUTH KOREA

The development of the electrical equipment goods sector in Korea is a recent fact, but the rate of growth seen during recent years reveals the extreme dynamism of this activity: in 1973 the production of equipment for the transmission and distribution of electricity accounted for US$ 15.2 million; in 1975 production was US$ 30.6m, whilst forecasts for 1980 are US$ 50m. At the same time exports have increased: in 1973 they represented 4% of the national production, but in 1975 they accounted for 15%[1].

In fact the Korean production of electrical equipment is concerned mainly with power and distribution transformers (cf. Table 2). At the present time the electrical industry is producing few items of equipment for the production of electrical energy, and Korea is dependent on foreign countries for a great part of its needs in equipment for the production of electricity. About twenty companies produce equipment for transmission and distribution (transformers, cables, etc.). All of these are Korean firms which have signed licencing agreements with foreign firms, mostly American and Japanese. These companies still obtain their supplies largely from foreign firms for the production of the equipment (special steels, ceramic parts, insulating paper, etc.); in the case of the Korean Han Yung Industrial Company the contribution of imported supplies accounts for 25% of the cost of the equipment produced. The future development of equipment for the production of electrical energy will certainly be carried out on the basis of the existing units. At the present time Korean companies produce industrial

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(1) Source: GMS Electrical Energy Systems.
US Department of Commerce.

TABLE 2 - KOREA

DOMESTIC MANUFACTURERS

Dae Myung Manufacturing
Transformers

New Korea Electric Co. (Licensee of Osaka Transformers, Japan)
Transformers

Han Yung Industrial Co. (Licensee of Westinghouse, USA)
Transformers, electric motors, pumps

International Electric Enterprise Co., Ltd., (Licensee of Takaoka, Japan)
Transformers, switchgear.

Brown Boveri & Cie (Switzerland)
HV transformers

In Chun Electric Mfg. Co. (Licensee of Toshiba, Japan)
Transformers

Kukje Electric Co. (Licensee of Kokan Mfg. Co., Japan)
Transformers

Lee Chung Electric Co. (Licensee of Toshiba Co., Japan)
Switchgear, generators, transformers, electric motors, condensers

Tai Han Electric Wire Co. (Licensee of Tokyo Electric Co., Japan)
Watt-hour meters

(as licensee of Nisshin Electric Co., Japan)
Capacitors

Kukje Wire and Cable (Licensee of Western Electric Co., Japan)
Cables

Union Electric (Licensee of Mitsubishi Denki, Japan)
Control panels

Dae Han Electric Wire (Licensee of Sumitomo Electric Co., Japan)
Cables

Hankuk Noble Co., (Licensee of Teikoku Communication, Japan)
Resistors and rotary switches

Hankuk Machinery Co. (Licensee of Lummus Co., USA)
Heat Exchangers

Shin Han Electric Co. (Licensee of Osaka Transformers, Japan)

Sam Yung Electric Industry Co. (Licensee of Chemical Condenser Co., Japan)
Condensors

Pung Sung Electric Co., Ltd., (Licensee of Osaki Denki Co., Japan)
Watt-hour meters, converters.

Gold Star Communication Equipment (Licensee of Fuji Musen, Japan)
Watt-hour meters

Gold Star Cable (Licensee of Hitachi Cable Co., Japan)
Electric wire cables

Source: GMS Electrical Energy Systems. US Department of Commerce boilers and could enter into the production of boilers for electric power stations. The Haukuk Machinery Company has built a unit for 24,000 diesel engines a year of 45 to 256 hp with the technical assistance of East Germany. The Chinil Industrial Company has units producing diesel engines; most of this production is directed towards uses for pumps or for marine engines, but these companies could also develop the production of diesel power stations based on these engines.

Summarizing, therefore, the productive capacity of the electrical equipment sector in Korea relates essentially to local companies with private capital whose technological support has been assured by licencing agreements signed with the major multinationals in the sector. Initially it was production for a national market which was developed (distribution and power transformers). However the growth of exports shows that the companies in the sector know how to enter the world market rapidly. Finally the companies are studying every opportunity to obtain support in the production of equipment for thermal, diesel or hydraulic power stations.