Distr:
GENERAL
E/ESCWA/ID/85/11
20 NOVEMBER 1985
Origional:ENGLISH

DEVELOPMENT OF SELECTED INDUSTRIAL BRANCHES NO.1

UNITED NATIONS

ECONOMIC COMMISSION FOR WESTERN ASIA

STUDIES ON REGIONAL CO-OPERATION IN THE DEVELOPMENT OF CAPITAL GOODS AND HEAVY ENGINEERING INDUSTRIES

E/ESCWA/ID/85/11

85-1280

ABBREVIATIONS

A/D	Analogue to digital
ARABSAT	Arab League Countries'Satellite
b/s	Bits per second
CK	Circuit or pair kilometres
D/A	Digital to analogue
dB	Decibel
DEL	Direct exchange lines
DSD	Direct subscriber dialling
ECWA	Economic Commission for Western Asia
FDM	Frequency division multiplex
H.F.	High frequency
Hz	Hertz
IBRD	International Bank for Reconstruction and Development
IC	Integrated circuit
ITU	International Telecommunication Union
Kg/cm^2	Kilogramme/square centimetre
m	Metre
m^2	Square metre
m^3	Cubic metre
MTBF	Mean time between failures
MWh	Megawatt hour
O & M	Operation and maintenance
OES	Order execution and service
OJT	On-the-job training
OMC	Operation and maintenance centre
PABX	Private automatic branch exchange
PAX	Private automatic exchange
PBX	Private branch exchange
PCB	Printed circuit board
PCM	Pulse code multiplex
PE	Ployethylene
PGS	Project generation system
PVC	Polyvinyl chloride
RAM	Random-access memory
R&D	Research and development
REPROM	Reprogrammable memories
SKM	Standard kilometres of cables; one kilometre of a cable having 100 pairs or circuits
SPC	Stored programme - control system
TC	Training centre
TEO	Technical efficiency and organization
TV	Television
V	Volt
VDU	Visual display unit
VF	Voice frequency

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PREFACE

This publication is the first of a series on development of selected industrial branches in the ECWA region that includes studies on regional co-operation in the development of capital goods and heavy engineering industries. These studies were undertaken as part of the Joint ECWA/UNIDO Industry Division's Work Programme on Regional and Co-operation in the Development of Capital Goods and Heavy Engineering Industries. This programme received financial support from the contributions of the Netherlands Government.

These studies are presented in two volumes. Volume I includes three parts. The first elaborates an overall framework for regional co-operation, namely an alternative partial strategy for industrial integration in the ECWA region. The second part presents the report of the Expert Group Meeting on Capital Goods and Heavy Engineering Industries, held from 15 to 19 June 1981 in Vienna, Austria. The third part presents the report of the Panel of Experts on Electric Power Generator and Turbine Manufacturing, which met from 3 to 5 October 1983 in Baghdad, Iraq. Volume II elaborates on specific areas for industrial co-operation, namely the viability of establishing a regional electric power equipment industry in the ECWA region, including identification of specific projects lending themselves to regional co-operation. The latter includes preparation of pre-feasibility studies on turbines, generators and transformers.

INTRODUCTION

Industrial development remains the motive force behind economic development. However, this motive force requires the development of a balanced and integrated industrial structure with strong forward and backward linkages within the industrial sector as well as with other sectors, so that the growth of industry becomes an organic process. The creation of a balanced industrial structure requires the development of a wider range of productive capacities in intermediate and capital goods and engineering industries. An integral part of the balanced industrial structure is the creation of strong technological capabilities, especially in capital goods and engineering industries, with the objective of reducing economic and political dependence.

An examination of industrial development in the ECWA region shows the dominant feature to be the increasing imbalance recorded in recent years between the existing pattern, structure and output of the industrial sector in member States, on the one hand, and the structure and pattern of demand for locally manufactured products, particularly capital goods, on the other hand.

The structure of manufacturing output in the region reveals its predominant orientation towards the production of consumer and intermediate goods. This industrial structure consists of a large variety of scattered enterprises including certain chemical formulations or engineering industry, assembly operation, with limited linkages between them and little complementarity in their production. More complex and integrated industrial activities in the field of capital goods and engineering industries have only recently been given limited attention by some member States. While the lack of resources and the limitation of the market at the national level may have prevented the establishment of such industries, the absence of a regional outlook in dealing with the problem of industrialization has certainly been an important added factor.

The demand for capital goods and engineering products has been growing at an exceptionally high rate due to the implementation of ambitious development programmes in member States. The limited internal production base and the fragmented nature of the industrial sector, combined with lack of complementarity in production, has been reflected in the phenomenal increase in imports.

Thus, the import of engineering products into the Arab League and the ECWA region increased from $1,351 million and $877 million respectively in 1963 rising to $39,854 million and $29,248 million respectively in 1979. In percentage terms, the Arab League region imported between 3 and 4.5 per cent of world exports in engineering products during the period 1963-1974, rising to 7 per cent in 1975 and to 9 per cent in 1980.

The ECWA region's share in world imports of engineering products increased from 2-3 per cent during 1963-1974 rising to 6 per cent in 1980, while the region's share in the total import of engineering products of the developing countries increased from 7.2 per cent in 1963 to 20 per cent in 1980.

When imports of engineering products are compared with MVA and GDP the figures are more impressive and revealing. Thus, while value added in manufacturing for the ECWA region used to equal approximately the value of engineering products imported in 1963, by 1980 the ratio was about 30 per cent. From 1963 to 1972, the ECWA region spent, annually, close to 10 per cent of its GDP on imported engineering products, rising to 15 per cent of GDP in 1980.

It is within this dynamic and expanding market that ECWA's programme on the development of capital goods and engineering industries has been conceived. In considering the possibility of formulating such a programme, at the national level, very few, if any, countries in the ECWA region will, in the foreseeable future, possess the minimum adequate market size and resources, or have an economic structure containing the necessary elements for the realization of such a programme and for creating an efficient and resourceful industrial sector within the economy.

ECWA's programme in this field aims at promoting the development of an integrated long-term regional pre-investment programme for the development of capital goods and heavy engineering industries, with strong linkages with related national industrial facilities. It is envisaged to be of a sufficient "mass" for providing the nucleus needed to develop industrial capacities and technological and mangerial capabilities in the field of engineering industries. This would bring the countries concerned to the take-off stage and provide a dynamic and flexible instrument for effecting future changes in this important field.

The programme for the development of capital goods industries should be considered primarily as part of an overall strategy for industrial integration basically aiming at building up mutually interlinked industrial capacities for promoting inter-Arab trade in manufactured goods leading ultimately to economic integration. This strategy draws on important concepts in the field of regional industrial planning and industrial location. To begin with, division of industrial activity in the region, while calling for individual countries to undertake large-scale production of particular products for the regional market, need not interfere with existing capacities; nor should it militate against the development of an industrial structure with diverse and versatile technological capabilties within each country. One need not think of regional co-ordination in terms of specialization in the strict sense or of a country-wise monopoly of industry.

An important objective of this programme is that it should attain a balance in the number and types of projects alloted to various countries for achieving an equitable distribution of benefits to be derived by participating member States.

According to set criteria basically conforming to concepts relating to regional planning and location, industrial sectors lending themselves to regional co-operation were identified generally to include selected capital goods and heavy engineering industries, petrochemicals, fertilizers, inorganic chemicals and agro-industries. The developmental rationale for the selection of these industries, in particular the capital goods and engineering industries, should be one of the basic objectives of the drive towards industrialization.

A set of three primary and three secondary criteria has been used as a guideline for identifying the regional projects under consideration. The first primary criterion relates to the size of the market. Accordingly industries have been considered candidate regional projects when the local demand in most countries taken separately is insufficient (in the foreseeable future - 15 to 20 years) to allow for the establishment of economically viable manufacturing facilities. The second criterion considers as potential regional projects those industries with strong forward and backward linkages and having the possibility of attaining a high local content through regional co-operation, rather than through establishing assembly plants within the boundaries of individual countries. The third criterion considers technology-intensive industries as aiming, in the longer run, at the organic development of high technological capabilities in the region. However, in the short term, priority should be given to the development of industries with relatively stable technologies and technological skills which can provide a basis for the longer run objective.

The first of the secondary criteria is the selection of industries with high economies of scale or which have economic viability through product mix, the elements of which are technologically interrelated. The second of the secondary criteria is the selection of those industries that lend themselves to production split whereby production of certain inputs or components can be decentralized, thus effecting economies of scale and affording even distribution of production capacities amongst ECWA countries, besides achieving a greater degree of vertical integration in industry. The third criterion relates to industries that have no critical locational factors and whose location is therefore determined with great flexibility.

Based on the above criteria, and after examination of the investment programmes in the ECWA region and the trends in imports, the specific areas that were identified under the ECWA programme include:

(1) Industrial machinery and equipment for petrochemicals, heavy chemicals and petroleum refining. This includes process vessels, storage tanks, bins, heat exchangers, reactors, furnaces and kilns, filters, pumps and compressors, industrial turbines, industrial boilers, etc;

(2) Electrical equipment, particularly for power generation, transmission and distribution systems, including generators, turbines, power boilers, transformers, motors, switchgear, condensers, rectifiers, capacitors, controls, cables and wires, etc;

(3) Communications equipment which includes broadcasting equipment, radar, exchanges, microwave and multiplex equipment, telex machines, telephone instruments, cables and wires;

(4) Electronic components, particularly semi-conductors;

(5) Construction and mining equipment which includes excavators, loaders, bulldozers, scrapers, graders, rollers, mixers, asphalt plants, cranes, hoists, crushers, piles, fork-lifts, etc;

(6) Agricultural machinery including tractors, tillage equipment, seeders, planters, fertilizer spreaders, pesticide sprayers, threshers and mowers, harvesters, trailers, etc;

(7) Motor vehicles and transport equipment;

(8) Industrial machinery and supplies for the petroleum industry;

(9) Machine tools;

(10) Steel and alloys industries.

Under ECWA's programme on capital goods and heavy engineering industries, which was initiated in 1978, a number of pre-feasibility studies or pre-investment studies have been prepared. These studies make forecasts for the next 15-20 years. Aside from examination of the techno-economic viability of candidate industries, the studies deal with important aspects relating to the development of this industry at the regional level. This includes linkages with national industries, the transfer and development of technology, standards, manpower training, development of regional industrial infrastructure, co-operative contractual arrangements with international manufacturers and industrial locations.

These studies were the subject of discussions in two expert meetings: (1) Expert Group Meeting on Identification of Projects for Regional Co-operation in Capital Goods and Heavy Engineering Industries, held in Vienna from 15 to 19 June 1981, and (2) Expert Panel on Electric Power Generator and Turbine Manufacturing held in Baghdad from 3 to 5 October 1983. The reports of these two meetings are included in Volume I along with a paper on industrial co-operation outlining an industrial integration strategy that provides the overall umbrella for ECWA's programme. A selected number of pre-investment and pre-feasibility studies have so far been completed and are presented in volumes I to II of this publication.

The Expert Group Meeting held in Vienna made specific recommendations concerning the projects which should be selected for development at the regional or subregional levels. The digital telephone exchange and transformer projects were considered by the Expert Group priority candidate projects for a regional industry. The digital telephone exchanges are technology-intensive. The costs of these products comprise about 25 per cent of the total cost of the telecommunications network. The studies indicated that the size of the market in the ECWA region through 1995 can accommodate four economically viable telephone exchange equipment manufactuing plants (each plant with a capacity of 250 thousand lines per year to be established in different ECWA subregions). Total investment was estimated at $340 million and total working capital at $96 million.

With respect to transformers, the regional market by the beginning of the 1990s will be able to absorb the output of three viable transformer factories:

(1) Small distribution (0.25-1.25 MVA) transformers, 6,000 MVA annual capacity;

(2) Medium power (6-40 MVA) transformers, 6,000 MVA annual capacity;

(3) Large power (75-200 MVA) transformers, 10,000 MVA annual capacity.

The total fixed investment for the three plants is estimated at $160 million and the total working capital at $38 million.

The Expert Group recommended that in addition to expanding existing facilities the market absorb two telephone cable projects. One new plant can be established immediately with an annual capacity of 2 million circuit kilometres expandable to 2.5 million later. The second plant could be established by the mid-1980s with annual capacity of 1 million circuit kilometres expandable to 1.5 million later. Total fixed investment for the new factories is estimated at $103 million and the working capital at $30 million.

The development of both the static chemical equipment1/ (volume II) and electric power turbines and generators (volume II, part 2) was considered by the Expert Group as extremely important. However, owing to the long gestation period of these projects and their complexities in terms of prerequisites in standardization, engineering capabilities and skills build-up, future detailed work will be required with a view to phasing in their development and implementation. The study on static chemical equipment indicated the economic viability of establishing two

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1/ ECWA, Development of Selected Industrial Branches, No.2, 1985.
2/ ECWA, Development of Selected Industrial Branches, No.2, 1985.

plants with capacities of 30,000 tons and 20,000 tons per year. The equipment to be produced includes mainly: pressure vessels, columns, furnaces, reactors and heat exchangers. The estimated total fixed investment is $200 million and total working capital $50 million.

As for power turbines and generators, the regional market can viably support one plant with an annual capacity of 5,000 MWh. Various other types of turbines and generators (for industrial, marine and other applications) can also be manufactured in the same factory. The estimated total fixed capital is $500 million and total working capital $100 million.

The Expert Group gave telephone instruments2/ (volume I) lower priority as a regional project. However, emphasis was laid on the need for co-ordination in the expansion of existing facilities at the regional and subregional levels. Further, it was felt that co-operation amongst these existing units should be effected in standardization of specifications and designs of components for eventual co-operation in specialized manufacture of components currently being imported.

The Expert Panel on Electric Power Generator and Turbine Manufacturing was held in Baghdad, Iraq, from 3 to 5 October 1983, as a follow-up to the Vienna Expert Group Meeting. The meeting was attended by experts from developing countries, representatives of the world's leading manufacturers of power generators and turbines, representatives of Arab investment and industrial development organizations and experts from electricity generation authorities. It was necessitated by the desire on the part of certain pan-Arab investment organizations to further elaborate on problems and prospects of establishment of turbine and generator manufacturing industries in the ECWA region (volume I, part 3). The main objectives of this panel were to acquaint the prospective promotors-investors with the problems and prospects of the industry in the region and to assist in formulating an approach and tentative course of action for phased establishment and development of turbine and generator manufacturing in learning from the experience of other developing countries and from the leading manufacurers of power generators and turbines.

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Part 2. REPORT OF THE EXPERT GROUP MEETING ON CAPITAL GOODS AND HEAVY ENGINEERING INDUSTRIES

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VOLUME I

PART I

INDUSTRIAL INTEGRATION - AN ALTERNATIVE PARTIAL STRATEGY

INDUSTRIAL INTEGRATION - AN ALTERNATIVE PARTIAL STRATEGY

In outlining a regional strategy, one should take into account the distinct features of the member countries in the ECWA region. These countries can be broadly classified into three categories:

The first category comprisses the oil-producing countries which, with the exception of Iraq and to a lesser extent Saudi Arabia, have limited natural resources apart from petroleum and natural gas. In addition, these countries have small markets that render inwardly oriented industrial development virtually not viable. The industries that could be developed and actually are being planned and developed are:

(1) Industies that are based on existing raw material mainly in petroleum and natural gas (chemicals and petrochemicals) in addition to marine resources;

(2) Industries that depend heavily on cheap energy (i.e., energy dependent basic metals);

(3) Capital-intensive and technology-intensive industries;

(4) Urban-oriented industries: namely foot-loose industries in addition to market-oriented industries where the cost of transport is high in proportion to the cost of the product.

A part from developing certain light consumer and construction material industries on a limited scale, oil-producing countries have geared their industrialization mainly towards the processing of raw materials and their export to the advanced economies. For their development, these industries have drawn largely on the technological and production resources available in advanced economies, whether capital or intermediate goods. Therefore, the technological skill that has developed has been applied only to a small proportion of the industries; its industrial dependence and interrelations have remained largely with the more sophisticated economies abroad. Industrial investments in such industries could not transmit their benefits to other sections of the economy by furthering the process of industrial growth nor by extending the input and output relationships in industry and accordingly they have failed to achieve the accumulative process of growth characteristics in industry.

The second category of countries includes those that are endowed with certain natural resources and except for Iraq, those that are not dependent on the oil sector. In these countries industrial development even for the relatively more advanced is still at an early stage; the industrialization process was primarily inward-oriented, with import substitution playing a leading role. The implemented industrial programmes, however, have not been systematically co-ordinated to build industrial capacities in interrelated fields. Thus, the structure that has emerged consists of a large number of assorted industries, largely light consumer ones which require simple technologies and do not complement one another. Another major group of industries has developed related to the construction material industries. Furthermore, the contribution of manufacturing to domestic product in most countries is smaller than expected and does not exceed 10 per cent in general.

The third category includes the least developed countries where economic and industrial development is at the formative stage.

The rationale of the need for industrial co-operation falls within the basic objectives of the drive towards industrialization. Industrial development remains the "motive" force for economic development. However, this requires the development of a balanced and integrated industrial structure with strong forward and backward linkages within the industrial sector as well as with other sectors, particularly agriculture, so that the growth of industry becomes an organic process. The creation of a balanced integrated industrial structure requires the development of a wide range of productive capacities in intermediate and capital goods and engineering industries. An integral part of the balanced industrial structure is the creation of strong technological capabilities especially in capital goods and engineering industries with the purpose of reducing economic, political and military dependence. In considering the possibility of formulating such a programme at the national level, very few, if any member countries in ECWA possess the minimum adequate market size and resources, or have an economic structure which contains the elements for the realization of such a programme and for creating an efficient and resourceful industrial sector within the economy.

A recent study on projecting industrial potential in the Arab countries brought into focus the possible effects of regional integration on industrial structure and growth. Two alternative scenarios were drawn up. The first assumes that each Arab State would remain separate and would not engage in any significant group participation beyond that which it has historically maintained. The second scenario depicts the results of grouping the Arab world into four integrated subregional entities.

The results derived indicated that in the second scenario:

(1) Value added in manufacturing would increase significantly by 30 to 50 per cent for two of the subregions, and for the remaining subregions by 200 to 450 per cent.

(2) The degree of industrialization measured by the ratio of MVA to GDP would rise significantly from 5.8 to 15.3 per cent in the first scenario to 22 to 30 per cent in the second scenario.

(3) The industrial structure that could emerge from following a collective self-reliance strategy might be more balanced with

intermediate and capital goods and engineering industries having a high share in total manufacturing.[1]

An important aspect of industrial integration relates to development of exports. This is particularly important for oil-producing countries that have concentrated their major industrial development drive in the development of export and resource-oriented industries that have a limited local market base and cater more to the international market. Regional intergration would provide in the long term and on a mutually beneficial basis a tied and broader regional market.

The above considerations point to the urgent need to promote co-operation in development efforts among the countries in this region, and the need to elaborate practical steps that can be taken to move towards this basic objective. In any co-operation arrangement special measures should be devised to accommodate the least developed countries of the region.

Broadly speaking, partial integration would call for the development of a number of new industries worked out as "packages" that would include more or less balanced benefits for all member countries in the co-operation arrangement. These "packages" should constitute an important and integrated part of the industrial sector. This is in contrast to an individual "plant" or "clusters of plants" approach.

A different strategy is envisaged for certain existing and proposed industries, primarily, chemicals, petrochemicals, and fertilizer industries concentrating, as a first phase, on co-ordination and co-operation measures. The over-all framework of such a strategy would include the following elements.[2]

(1) Co-ordination and co-operation in the production of feedstock for these industries. This would include achieving a good balance between aromatics and olefins. In view of the chemical properties of Middle Eastern crudes (low in naphthenes), it is advisable to develop initially one or two petrochemical refinery complexes for the production of aromatics on a subregional level;

(2) Co-operation in the fields of projects construction, operations, and transfer of technology and training;

1/ Industrialization in the Arab World Options and Strategies Year 2000. Jointly prepared by the secretariats of the United Nations Econmic Commission for Western Asia and the United Nations Industrial Development Organization, January 1980.

2/ For more details, see "Basis for Formulation of Strategies Pertaining to Development of the Petrochemicals Industry in ECWA region", prepared by the Joint ECWA/UNIDO Industry Division, ECWA 1980 (unpublished).

(3) Working out a co-ordinated strategy for marketing their products and affecting a breakthrough in the international market in developed and developing countries, which is dominated by the multi-national;

(4) Developing the regional Arab market by formulating mutually beneficial "packages" of industries that would include the feasible splitting of production processes whereby intermediate processing would be undertaken near oil sources while certain feasible downstream operations would be located near the markets.

However, the partial integration strategy should be considered as the first phase in a process that aims at the planning and development of certain industrial branches and sectors on a regional basis leading ultimately to complete economic integration.

Identification of industries and sectors for co-operation

In drawing up a strategy for regional co-operation, one may draw on important concepts in the field of regional industrial planning and industrial location. To begin with, division of industrial activity in the region, whereby individual countries undertake large-scale production of certain commodities for the regional market need neither interfere with existing capacities, nor with the development of an industrial structure with an all-sided technological capacity within the countries. One need not think of regional co-ordination in terms of specialization in the strict sense, or of national monopolies of industry. "Regional" plants for a particular industry could be located in more than one country according to expanding market needs. Thus, a number of industries might be subjected to a combination of market and resource pulls. This is especially important in industries when economies of scale are obtaining in addition to a relatively high proportionate cost of transport, to the value of final products. Such a plant when producing for the regional market would be subject to time phasing whereby with an expanding market one or more plants in different locations might be needed to optimize regional benefits. In time, differences between regional plants and national plants would become flexible. Furthermore, plants which might be considered "regional" in some subregions of ECWA might be only national plants in other subregions.

In the ECWA region, industries that lend themselves to regional co-operation fall into one or a combination of the following types:

(1) Industries that are resource-tied, the location of which is determined by economic access to the main raw materials;

(2) Industries with high economies of scale;

(3) High energy-consuming industries;

(4) Industries with a high return to scale and a relatively low proportionate cost of transport to the value of final products;

(5) Industries where economic viability is generally achieved by producing a "product mix" that is technologically related;

(6) Industries that lend themselves to the splitting of production whereby certain products can be produced in one location for use as inputs in one or a number of plants in other locations, i.e. assembly operations, productions of parts and components, inputs;

(7) Downstream intermediate products where the economic advantages of the resources tied decrease as one goes downstream in the production process (i.e. petrochemical downstreams and end-products);

(8) Industries that are mobile, and whose location can be determined with greater flexibility.

The industries and industrial sectors that lend themselves to regional co-operation include the following:

(1) Petrochemicals, fertilizers and inorganic basic chemicals. The petroleum-based industries include not only the export-oriented industries, but also those industries that cater for the regional market as well as those downstream industries that could be located away from sources of energy. As for inorganic basic chemicals these could include mainly phosphate-based industries and industries based on common salt deposits and Dead Sea brine;

(2) Basic metal industries, possibly including iron, steel and aluminium;

(3) Heavy engineering and capital goods industries, including process equipment for petroleum refining, petrochemicals and other heavy chemical industries, cement manufacture and brick-making equipment, construction equipment, heavy electrical engineering equipment;

(4) Electronics and telecommunication equipment, including radio and television receivers, telegraph and telephone equipment, microwave equipment, and components and auxiliaries for electronic equipment;

(5) Certain durable consumer goods industries;

(6) The automobile industry;

(7) Agro-industries.

Table A presents industrial sectors, industries and candidate projects for regional co-operation identifying the importance of the eight characteristics outlined above.

<u>ECWA programme for regional co-operation in capital goods and heavy engineering</u>

The demand for engineering products has been growing at an exceptionally high rate due to the implementation of ambitious development programmes in member States. The limited internal production basis and the fragmented nature of the industrial sector combined with lack of complementarity in production have all reflected themselves in the phenomenal increase in imports.

Thus, the import of engineering products into the Arab League and the ECWA region increased from $1,351 million and $877 million respectively in 1963 rising to $39,854 million and $29,248 million respectively in 1979. The Arab League region imported between 3 and 4.5 per cent of world exports in engineering products during the period 1963-1974, rising to 7 per cent in 1975 and to 9 per cent in 1980.

Engineering products destined for the Arab League region represented about 11-14 per cent of the total imports of developing countries during the period 1963-1975, rising to about 30 per cent in 1980.

The ECWA region's share in world imports of engineering products increased from 2-3 per cent during 1963-1974 rising to 6 per cent in 1980 while the region's share in the total imports of engineering products of the developing countries increased from 7.2 per cent in 1963 to 20 per cent in 1980.

When imports of engineering products are compared with MVA and GDP the figures are more impressive and revealing. Thus, while value added in manufacturing for the ECWA region used to equal approximately the value of engineering products imported in 1963, by 1980 the ratio was about 30 per cent. With respect to GDP between 1963 and 1972, the ECWA region spent, annually, close to 10 per cent of its GDP on imported engineering products, rising to 15 per cent of GDP in 1980.

It is within this dynamic and expanding market that the development of capital goods should be considered. ECWA's project aims to develop an integrated long-term regional pre-investment programme for the development of capital goods and heavy engineering industries, strongly linked with related national industrial facilities. This programme should be of sufficient "mass" and large enough to provide a nucleus from which industrial capacities and technological and managerial capabilities in the field of engineering industries can develop to the take-off stage, and to provide an instrument that will be dynamic and flexible enough to effect future changes in this important field.

Another important objective of this programme is to attain a balance between the number and types of projects, which will permit an equitable distribution of benefits among participating member States.

Aside from the examination of the techno-economic viability of candidate industries, the programme deals with important aspects relating to the development of this industry at the regional level. These include linkages with national industries, the transfer and development of technology, both hardware and software, standards, manpower training, development of regional industrial infrastructure, financing, promotion and incentive measures and policies, co-operative contractual arrangements with international manufacturers and industrial location.

A set of primary and secondary criteria has been used in the selection of candidates for regional projects in capital goods industries.

The primary criteria include:

(1) Industries where the local demand for their products in most countries of the ECWA region is not likely to be sufficient within the next 15-20 years to enable them to establish economically viable manufacturing facilities;

(2) Industries with strong forward and backward linkages where a high local content can be attained through regional co-operation as against establishing individual assembly plants within the boundaries of individual countries;

(3) Technology-intensive industries requiring the development and building up of domestic high technological capabilities. This is the longer-term objective. In the short-term, however, priority should be given to the development of industries with relatively stable technologies and with those technological skills needed for attaining the longer-term objective.

The secondary criteria include:

(1) Industries with high economies of scale and/or industries where economic viabilities are generally obtained by producing a product mix that is technologically related;

(2) Industries that lend themselves to production split whereby certain products can be produced in one location for use as inputs in one or a number of plants in other locations, i.e. assembly operations production of parts and components, intermediate inputs;

(3) Industries that are "mobile" and whose location can be determined with a greater flexibility.

Table A

Industrial sector, industries and candidate projects for ECWA regional co-operation

Sector or industry	Important characteristics for regional co-operation*							
	I	II	III	IV	V	VI	VII	VIII
A. Petrochemicals Basic Olefins	x	x	x					
Ethylene								
Prophlene					x			
Butadiene					x			
Basic Aromatics	x	x	x		x			
Benzene								
Xylenes								
Intermediate and final products					x	x		
Ethylene Glycol	x	x			x	x		
High density polyethylene (HDPE)	x	x				x		
Low density polyethylene (LDPE)	x	x				x		
Vinyl Chloride Monomer (VCH)	x	x	x		x	x		
Polyvinyl Chloride (PVC)	x	x				x		
Styrene	x	x			x	x		
Polystyrene	x				x	x		
SBR				x	x			
Polybutadiene					x	x		
Polypropylene (PP)	x	x			x	x		
Acrylonitrile					x	x		
Dimethyl Terephthalate (DMT)		x	x		x			
Terephthalic Acid (TPA)	x	x	x		x			
Caprolactam					x			
Plasticizers				x			x	

* See text for details (page 12)

Table A (Cont'd)

Sector or industry	Important characteristics for regional co-operation* I	II	III	IV	V	VI	VII	VIII
Polyester Fiber				x			x	
Nylon				x			x	
Acrylic Fiber				x			x	
Synthetic rubber				x			x	
Carbon Black	x	x				x		
Formaldehyde	x	x						
Phenol Formaldehyde	x	x						
Melamine Formaldehyde								
Urea Formaldehyde	x	x						
Protein								
Graphite Electrodes	x	x						
B. Fertilizers								
Ammonia/Urea Complexes	x	x		x				
Phosphate Fertilizers	x	x		x				
Potash Fertilizers	x	x		x				
Mixed Fertilizers						S	x	
C. Basic Chemicals								
Caustic Soda	x	x						
Soda Ash	x	x						
Salt Cake*	x							
Sodium Silicate*	x							
Sodium Bicarbonate*	x							
Sodium Hypochlorite*	x							
Hydrochloric Acid*	x							
Bromine*	x							
Ethylene Bromide*								
Alkali Bromide*	x							
Methyl Bromide*	x							
Potassium Sulphate*	x							
Magnesium Oxide*	x							

* See text for details (page 12).

Table A (Cont'd)

Sector or industry	Important characteristics for regional co-operation* I	II	III	IV	V	VI	VII	VIII
Magnesium Hydoxide*	x							
Magnesium Choloride*	x							
Magnesium Silicate*	x							
Alkali Magnesium Carbonate (Dead Sea Brine based Chemicals)								
D. Metallurgical industries								
Steel Complexes (mainly direct reduction)		x	x			x		
Aluminium reduction plants		x	x			x		
Alloys and ferro alloys		x	x			x		
Peletizing plant		x				x		
Central foundry		x				x		
Central forge		x				x		
Pipe manufacturing		x						
Seamless tubes		x						
E. Engineering and capital goods								
Heavy electrical engineering equipment		x			x	x		
Telecommunication equipment		x			x	x		
Electronics components		x				x		
Construction equipment		x			x	x		
Agricultural machinery		x			x	x		
Process equipment for petroleum refining and petrochemicals		x			x			
Equipment for oil brick-making								
Exploration and development		x			x			
Machine tools		x			x			
Cement and equipment		x			x			

* See text for details (page 12)

Table A (Cont'd)

Sector or industry	Important characteristics for regional co-operation* I	II	III	IV	V	VI	VII	VIII
Textiles equipment		x			x			
Passenger cars		x			x	x		
Commercial vehicles		x			x	x		
Diesel engines		x				x		
Petrol engines		x				x		
Components for car manufacturing		x				x		
Consumer durables		x			x	x		
Components for consumer durables		x			x			
F. Agro- industries								
Sugar	x	x				x		
Vegetable oil	x	x				x		
Food canning and preserves	x	x						

* See text for details (page 12).

VOLUME I

PART 2

REPORT OF THE EXPERT GROUP MEETING ON IDENTIFICATION OF PROJECTS FOR REGIONAL CO-OPERATION IN CAPITAL GOODS AND HEAVY ENGINEERING INDUSTRIES

15-19 JUNE 1981, VIENNA, AUSTRIA

PREFACE

The Expert Group Meeting on Identification of Projects for Regional Co-operation in Capital Goods and Heavy Engineering Industries was held at the International Centre in Vienna, Austria, from 15 to 19 June 1981. The meeting was sponsored jointly by the United Nations Industrial Development Organization (UNIDO) and the Economic Commission for Western Asia (ECWA).

The following specific candidate regional projects for which pre-feasibility studies or pre-investment studies have been made by ECWA, were presented for discussion at the meeting:

(1) Telephone exchanges
(2) Telephone instruments
(3) Electric power turbines and generators
(4) Transformers
(5) Telephone cables
(6) Power cables
(7) Equipment for chemical industries
(8) Construction, agricultural machinery and automobile manufacturing.

The experts evaluated the identified regional projects, selected those that lent themselves to regional development and gave priority to their implementation. In addition, they examined common issues and problems relating to their establishment at the regional level including transfer of technology, manpower training, standardization, and machinery for implementation.

The global aspects relating to the establishment and development of this industry in developing countries, particularly the main issues to be presented in the UNIDO First Consultation Meeting on Capital Goods, which was scheduled to be held in Brussels in September 1981, were also presented and discussed in the meeting. Annex II contains the list of documents.

The opening session was addressed on behalf of UNIDO by Mr. Farlan Carr, Deputy Executive Director, UNIDO, and on behalf of ECWA by Mr. Ribhi Abu El-Haj, Chief, Joint ECWA/UNIDO Industry Division. The meetings were co-chaired by Mr. R. Abu El-Haj and Mr. Ivan Angelov, Head of Sectoral Studies Branch, Division of Industrial Studies, UNIDO.

In the closing session which was held on 19 June 1981, the recommendations and report of the meeting were adopted.

Experts attending included those involved in aspects related to the development of capital goods industries in ECWA member States, as well as international experts from outside the region and experts from regional and international organizations. The experts participated in the meeting in their individual capacities, rather than as representatives of the governments or organizations to which they belong. (For a list of participants see annex I.)

Part 1 of the report deals with evaluation of the identified projects. For each of the identified projects a summary of ECWA studies has been presented followed by a summary of discussions that also includes specific comments and recommendations by the experts. Parts 1 and 2 of the report deal respectively with common issues and problems associated with the development of regional industrial projects, and with UNIDO's Global Consultation Meeting.

RECOMMENDATIONS

A. General recommendations

In the ECWA region, the adoption of independent national development industrial strategies and policies has resulted in the creation of watertight compartments comprised of small individual markets offering an identical and narrow range of manufactured products. This has led to the creation of competing production structures instead of complementary ones. The narrow inward-looking approach to industrialization in most countries of the region has reduced investment opportunities in the industrial sector. The more recent outward-looking industrialization strategy in a number of member countries has concentrated primarily on the promotion of heavy investment in industries that cater essentially for markets outside the region. This enclave-type of industrial development is contributing further towards the region's dependence on the outside world, most particularly the advanced industrialized countries, the main users of the products of such industries. Sectoral imbalances unfavourable to capital goods industries, the development of which is considered highly strategic and essential to the developmental needs of the region, are clearly visible.

The Expert Group was of the opinion that if the above situation is to be rectified, an integrated approach to industrial development will have to be followed. This would involve co-ordinating the capital goods industrial development programme of countries on a regional basis, and creating dynamic complementarities in the sector within the region.

The Expert Group commended the work of ECWA in the identification of projects for regional co-operation in the field of capital goods and considered it a pioneering and initial effort in the direction of developing an integrated long-term regional investment programme with strong linkages. ECWA must continue these efforts. In this respect, the group recommended that ECWA, UNIDO, and UNCTAD, in close collaboration with the regional commissions, regional inter-governmental organizations and development institutions, should actively engage in exploring further possibilities of regional and interregional co-operation in capital goods and engineering industries within the context of the south-south dialogue.

B. Specific operational recommendations

Having reviewed the pre-investment studies in the capital goods sector carried out by ECWA, and bearing in mind the high economies of scale, the linkage and transfer of technology effects, as well as other considerations relating to the feasibility and benefit derived from these industries, the following recommendations were made:

(1) The digital telephone exchange and transformers were considered by the Expert Group to be priority candidate products for a

regional industry. It was therefore recommended that ECWA should present the projects to the member governments, the Arab Industrial Investment Co. (AIIC) and other concerned regional organizations for their consideration and for devising practical measures leading to the implementation of these projects.

(2) The Experts recommended that ECWA should present the projects on telephone cables to the member governments, AIIC and other interested regional organizations for them to consider and to devise practical measures to implement on a reginal basis, as the technological requirements were not of a high order. These industrial units could be established quickly, they are lucrative and require specialization in materials and marketing management.

(3) The Experts considered that the development of both the static chemical equipment and electric power turbine and generator industries were extremely vital to the interests of the Arab countries. However, due to the long gestation period of these projects and their complexities in terms of prerequisites in standardization, engineering capabilities and skills build-up, more details were required with a view to phasing out their development and implementation. The Group recommended that this should be undertaken by ECWA with assistance from APICORP, OAPEC and AIIC and other regional organizations concerned, with a view to exploring the possibility of further action regarding implementaiton of these projects.

(4) In view of the fact that in the region there were already a number of enterprises manufacturing low tension power cables, the Expert Group recommended that, to meet the market requirements for high tension cables, the existing units should be encouraged to expand into higher technology power cable manufacture by the addition of XLPE lines. The need for standardization should be met through the respective national standards organizations and ASMO.

(5) With respect to telephone instruments, the Group felt that in view of the existing production capacities, steps should be taken towards strengthening existing national factories with the possibility of expansion on a sub regional basis. Co-operation among these units should also take the form of specialization on manufacture of components.

(6) With respect to construction, agricultural equipment and automobile manufacture, which all use similar components and manufacturing processes, the Group considered that these industries should be developed in an integrated manner to derive the benefits of scale economies linked to the manufacturing technologies, the regional markets and distribution of economic benefits among member States. The Group noted with satisfaction the steps taken by Iraq and Algeria towards establishing these industries in an integrated manner and recommended that a regional aproach be taken in considering their future development. The Group considered that ECWA and UNIDO should combine their efforts with AIDO, AIIC and other relevant regional organizations in order to strengthen the regional development of these industries.

I. EVALUATION OF IDENTIFIED REGIONAL PROJECTS

A. Manufacturing telecommunication equipment

1.1 Basic economic and technological considerations- summary of ECWA study[1/]

The major telecommunication services in the region, at present and for the foreseeable future, are telephone and telex. The introduction of telex into the region has been fairly recent. The role of telegraphy has diminished because of improvements in long distance and international telephone services and the introduction of telex. Bulk data communication is not expected to become significant during the projection period (1980-1995).

The present status of telecommunication services - mainly telephony - in terms of service penetration (density), availability (ratio of working connections to expressed demand), and quality varies considerably within the region. The small Gulf States (Bahrain, Kuwait, Qatar, United Arab Emirates and Lebanon are substantially more advanced that the rest of the region.

In the region as a whole, and even in the relatively more advanced countries in ECWA, the development of these services has been lagging behind many other regions and countries of the world, including some in similar states of economic development (measured in terms of GDP). The rate of growth of telecommunications in the region has lagged behind the growth of the economy which contrasts with the trend in developed countries.

The inadequacy of the telephone service is manifested by:

(a) Poor service quality: limited direct subscriber dialling facilities, frequent outages, long delays in securing long distance and international connections, etc.;

(b) Long waiting lists of people applying for the service, and long waiting time;

(c) Low telephone density;

(d) Disparity between urban and rural telephone densities;

1/ ECWA, Joint ECWA/UNIDO Industry Division, The Viability of Establishing A Regional Telecommunication Industry in the ECWA Region, Basic Economic and Technological Considerations (Volume I) Development of Selected Industrial Branches No.2, 1985

(e) Substantial pent-up demand which is not revealed by published statistics.

The poor state of telecommunication services is due to inadequate investment in the telecommunication sector. This has affected the national networks in many ways:

(a) Some equipment is worn out; the Egyptian network is a glaring example. An IBRD study recommended that it should be replaced by a new network;

(b) Other equipment and systems are technologically out-dated or obsolete: manual exchanges, open wire lines, HF transmission, etc;

(c) Overloading and congestion of circuits;

(d) Inadequate maintenance and repair work.

The inadequacy of the services at present also implies a great potential for their growth in the future. In fact, an increasing awareness of the importance of telecommunication services has been developing in all countries of the region. This is indicated by:

(a) Current projects for upgrading and expanding the national networks. The trend is towards greater use of automatic exchanges, PCM multiplex in the local network, buried cable in the outside plant, coaxial cable and microwave radio-relay transmission systems for long distance service, satellite communications for international service, etc.;

(b) Country plans and stated objectives relating to future network development

The demand for telecommunication services is generally determined by:

(a) The social environment: demographic development, people's preferences and habits, etc.;

(b) The economic environment: level and structure of the GNP,distribution of income, cost of telecommunication services, etc.;

(c) The technological environment: development of new products and systems that offer new or improved services

Only part of the demand for telecommunication services in the region is expected to be satisfied because their growth is not governed by the free interplay of market forces. Instead, it is constrained by government policies which regulate the allocation of resources (capital, manpower, etc.) according to the following criteria:

(a) National priorities which govern the inter-sectoral distribution of resources among competing sectors.

(b) Sectoral priorities which govern the intra-sectoral distribution of resources among competing services within each sector, e.g. telephony, telex, etc.

The projected growth of telecommunication services undertaken for the purpose of this study and the resulting densities, for the ECWA region as a whole, are shown below:

	Actual	Projections			
	1975	1980	1985	1990	1995
(a) Number of DELs	1 217 864	3 167 000	5 332 000	9 310 000	14 215 000
(b) Telephone density (Number of DELs per 100 people)	1.48	3.4	5.0	7.6	10.1
(c) Number of telex subscribers	5 133	45 200	97 100	173 700	n.a.
(d) Telex density (Number of telex subscribers per 10,000 people)	0.62	4.8	9.0	14.8	n.a.

Even with the significant projected increase in telephone lines and telex subscribers, the resulting densities will still be far below world standards. The growth rate of main lines will slightly exceed the growth rate of the economy which indicated substantial improvement compared to past performance.

The growth of telecommunication equipment was derived from the projections above.

	Average annual increase		
	1981-1985	1986-1990	1991-1995
(a) Telephone exchange lines	433 000	796 000	981 000
(b) Telephone instruments	563 000	1 035 000	1 275 000
(c) Telex exchange lines	9 980	15 320	n.a.
(d) Telex machines	9 980	15 320	n.a.
(e) PVM channels	25 980	47 760	58 860

Projections regarding cables were made and have been analyzed under cables manufacturing, section B, 1.5; projections regarding other equipment such as microwave radio-relay and FDM multiplex equipment were not made because of inadequate data.

The corresponding average annual investment in the region's networks is estimated as follows:

Period	Millions of US dollars (at constant 1979 prices)
1981-1985	886
1986-1990	1 622
1991-1995	2 000

The ratio of investment in telecommunications to national income during the projection period will be between 0.3 and 0.6 per cent which is barely within the world average (0.4 to 1.0 per cent). Although this represents substantial improvement compared to past performance, the projected rates of investment will not be sufficient to produce great and fast improvements in the telecommunication networks. ECWA countries must invest considerably higher proportions of their national income than the world average, which in fact reflects investments for normal growth of telecommunications in developed countries.

The distribution of investment within the telecommunication network indicates that exchanges and the outside plant (mainly cables) account for about 25 per cent each of the total cost of adding a main line. The projected investment in equipment is shown below:

	Average Annual Investment (Millions of US Dollars) at Constant 1979 Prices		
	1981-1985	1986-1990	1991-1995
(a) Telephone exchanges	173	318	392
(b) Telephone instruments	23	41	51
(c) Telex exchanges	4	6	n.a.
(d) Telex machines	40	61	n.a.
(e) Multiplex equipment	35	64	78
(f) Local network cables	180	321	400

Examination of the supply aspect of telecommunication equipment indicates that the telecommunication industry may generally be described as follows:

(a) Technology-intensive; relying heavily on the outcome of its R&D efforts. The average investment in R&D is about 10 per cent of the value of sales;

(b) Capital-intensive; the work force it requires is relatively small and skilled;

(c) A heavy user of intermediate products from other industries, particularly electronic components. Because the manufacture of these components is subject to economies of scale and because of their high cost of R&D, most telecommunication equipment manufacturers procure them from specialized component manufacturers. Consequently, the value added obtained in the manufacture of telecommunication equipment is generally low and most of the value added can be obtained by assembly production;

(d) Highly competitive;

(e) Dominated by a few multinational corporations which control the supply of equipment and technology;

(f) A stimulating influence on the development of other industries; it has generated demand for their products (e.g. electronic components and data processing industries), and made available to them the fruits of its research programmes;

(g) A substantial contributor to the general economic development, compared with most other industries;

(h) An industry which has generally grown more rapidly than the national economy in terms of annual production and investment.

The major problems facing the establishment of telecommunication equipment industry in developing countries are:

(a) Ability of the domestic market to absorb the output of the local industry;

(b) Acquisition of technology, including new product designs and production processes, and the required skills;

(c) Development of an organization which could implement projects of this scope and nature;

(d) Development of supporting industries, particularly electronic components and data processing industries. The role of those industries in serving other industries (e.g. industrial and consumer electronic products etc.) should also be taken into account;

(e) Proper rate of development of the industry: if the rate were too slow, the dynamism of growth would be hampered because of economic dislocations. The possible negative results would include a meagre return on investment and strangulation of capital inflow. On the other hand, if the rate were too rapid, large amounts of money would be required, possibly straining available resources and consuming large amounts of foreign currency.

The issues outlined above apply to the ECWA region where the existing telecommunication-equipment industries are limited and carried out on a purely national basis. The main equipment produced is electro-mechanical (crossbar) exchanges and telephone instruments in Egypt, Syria and Iraq. Syria is also setting up facilities for producing digital exchanges, probably on an assembly-type basis.

The manufacture of telecommunication equipment is analyzed in the study in the context of a regional industry. Its home market would be the collective markets of the region, and it might establish factories in various countries of ECWA. The form which it would take would have to be determined in subsequent feasibility studies.

The relative advantages of a regional industry vis-a-vis a national industry are:

(a) A larger market which will reduce the unit cost of production, and stimulate the transfer of technology to the region because integrated production becomes more feasible;

(b) More efficient use of resources (capital and skilled labour) in the region as a whole; duplication of projects would be prevented;

(c) Development of regional co-operation with its social and economic advantages to the people of the region.

On the other hand, a regional industry faces unique problems stemming from its links with numerous governments and telecommunication administrations. A prerequisite to its success is the continuous co-operation among governments of the region. Without that it is doomed to failure.

The regional industry must establish links with the following:

(a) Telecommunication administration: For proper production, planning, product marketing, standardization of equipment, development of operational software, installation and commissioning of manufactured equipment, after-sale logistic services, etc. The local industry must be able to perform all the tasks that are usually performed by foreign suppliers of equipment;

(b) Governments of the region: For resolving issues relating to trade policies, protective measures, training of staff in local institutions, acquisition of capital, etc.;

(c) Sources of technology: Mainly international manufacturers of telecommunication equipment, for setting up the plant, supplying design and production documents, training of local staff, etc.

The selection of candidate products for regional manufacture is based on the following criteria:

(a) Technological development: Products that are expected to become outdated or obsolete should not be selected;

(b) Market size: The ability of the regional market to absorb the output of an integrated production industry and the inability of individual national markets to absorb the output of such an industry.

The selected products should be ranked according to their relative value, their impact on the performance and cost of the whole network, their contribution to the transfer of knowledge and skills, and the resources required for manufacturing them.

The expected technological developments, at least during the projection period (up to 1995), are:

(a) Networks: Analogue networks will be converted to the digital form because of performance and cost advantages. However, because of the huge investment already made in existing analogue equipment which is both reliable and durable, the conversion process will be gradual and there will be mixed analogue and digital networks for some time;

(b) Exchanges: The trend will continue towards the electronic digital exchanges. Future developments will mainly reflect improvements in electronic devices (intermediates);

(c) Multiplex equipment: PCM will be increasingly used until all the national networks are digital. In addition to its use in the local network, which has already proved to be economically advantageous, it will compete with FDM in long-distance transmission;

(d) Telex machines: The mechanical parts of present-day teleprinters will be replaced by electronic devices. Faster printers and visual display units will be used in the future. The technology of telex machines will therefore undergo a major change. This equipment should not be considered for manufacture;

(e) Telephone instruments: It is very likely the telephone will be the last piece of equipment to become digital because the cost will not be justified until the rest of the network has become digital. Thus, analogue instruments will continue to be used for a long time. However, push-button dialling will become more common because of its advantages e.g. signalling in conjunction with digital exchanges.

(f) Microwave equipment: This includes specialized products, such as wave guides and antennaes. Electronic equipment is 30 per cent of the cost of microwave equipment. Thus, microwave equipment is not a priority item for local manufacture.

(g) Cables: The advent of optical fibres as potential substitutes for conventional cables can render the latter completely obsolete. The transmitters and receivers of this newly developed transmission system are electro-optical; the medium is very thin glass fibres. This system has a very large capacity, and immunity from electromagnetic interference and noise. It has been introduced to a limited extent in the United States and other technologically advanced countries. Initially, it is expected to be used to connect large exchanges in heavily congested areas. However, in the local network which accounts for the greatest portion of cable, the system will not be introduced within the projection period partly because of the cost of replacing existing cables which are expensive, reliable and durable. It must be added that telephone cables should be manufactured together with electric power cables, control cables, etc., by a separate industry (see cables manufacturing section B). They have no manufacturing links with other electronic-based equipment.

Examination of exchanges, telephone instruments, and multiplex equipment according to the criterion of market size indicates:

(a) Telephone exchanges: The regional market can easily absorb the output of an integrated production industry (about 250,000 lines per annum, according to international manufacturers). On the other hand, only the Saudi Arabian market could absorb the output of such an industry during the period 1986-1990 and beyond;

(b) Telex exchanges: The market for this product is not adequate even at the regional level;

(c) Telephone instruments: The regional market can absorb the output of an integrated production industry (about 150,000 instruments). On the other hand, the Saudi Arabian and Iraqi markets can each absorb the output of such an industry in the period 1986-1990 and beyond;

(d) Multiplex equipment: No conclusions can be drawn at this time because the necessary data are not available.

Based on the above analysis it seems that the telephone exchange is potentially the most promising candidate for regional manufacture. Telephone instruments are not a high priority. This preliminary conclusion was further examined in detailed pre-feasibility studies.

1.2 Pre-feasibility of manufacturing telephone exchanges-summary of ECWA study1/

The digital (time-division) telphonne exchange was chosen for this study because of its advantages over ananlogue exchanges, which include:

(a) Reduced initial and running costs of the exchange, and cost savings in the network as a whole;

(b) Improved performance in terms of voice quality, traffic capacity, connection speed, reliability and durability;

1/ Joint ECWA/UNIDO Industry Division, The Viability of Establishing a Regional Telecommunication Industry in the ECWA Region, (volume I), Pre-feasibility Study on the Telephone Exchange, (volume I, part 2), Development of Selected Industrial Branches No.2, 1985.

(c) Improved exchange management with respect to its operation and maintenance as well as the recording and organization of traffic information. These tasks are easily performed by means of software;

(d) Its introduction into analogue networks facilitates their conversion to the digital form, with resulting improvements in performance and cost;

(e) The complete reliance of the digital exchange on electronic components facilitates joint manufacturing of other electronic-based telecommunication equipment, increases the potential market for a possible regional electronic components industry, and stimultates the growth of other electronic equipment industries, especially in the fields of communications and data processing.

The main features of the digital exchange are:

(a) All functions are performed electronically;

(b) Heavy reliance on software, both for producing the exchange and for managing it in the network;

(c) Functional modularity: a fault in one module can be located quickly and corrected without disrupting other modules;

(d) Flexibility: the system can be designed with distributed switching in the form of subscriber concentrators remotely located from the parent exchange. It can also be interfaced with all types of signals and equipment; hence its introduction into analogue networks does not create incompatibility problems;

(e) The use of digital exchanges necessitates the formulation of a national synchronization plan. All PCM systems must be synchronized to a local time-base set by the exchange master clock. This feature does not exist in analogue networks;

(f) The mechanical structure of the exchange embodies modularity. The magazine or mechanical frame, with its printed circuit board assemblies, forms the basic mechanical unit. The magazines and connecting cables are housed in simple shelf structures, racks and cabinets.

Although the manufacturing data (including cost data) used in this study pertain to typical exchange models (with specific number of subscriber lines, number of trunks, and percentage of local traffic), they can be regarded, for the purposes of this study, as representative of the entire range of digital exchanges.

Two plant capacities were analyzed: 250,000 and 500,000 exchange lines. Starting with an annual output of 250,000 exchange lines, the level of industrial integration will be maximized - only electronic components will still have to be procured. In both cases, full capacity would be attained within six years. The maturation period consists of a three-year pre-production (construction) phase and a three-year production phase.

The manufacture of the exchange will require the manufacture of hardware and software. Software load tapes will be produced in close co-operation with the customer (the telecommunication administration). Hardware production will include procurement and inspection of electronic components, fabrication of metal and plastic parts, fabrication and equipping of printed circuit boards, assembly and testing. In general, many assembly operations could be performed manually, whereas testing is highly automated.

The production equipment and materials, including electronic components required for manufacturing the exchange, are mainly standard items available on the world market. A limited amount of equipment (special test equipment) and components is normally developed by exchange manufacturers; their acquisition is subject to licence agreements. Production equipment and materials could be purchased with the help of the collaborating international manufacturer.

As many assembly operations are labour-intensive, the required work force is mostly highly skilled; it is non-existent in the region, however. The development of a capable work force is one of the most important conditions for the success of the regional industry. Staff training, which must be initiated right at the start of the pre-production phase will be a permanent function at the factory.

The manufacture of the digital exchange can only be pursued with the collaboration of international manufacturers; the requisite technology is not yet available in the region. The scope of industrial assistance sought, and the form of co-operation (joint venture, licensing agreement, etc.) should be precisely formulated in the project feasibility study. In principle, industrial assistance is required for the following activities:

(a) Marketing of the product;

(b) Specification of manufacturing requirements: production equipment and materials, work force, factory buildings, etc.;

(c) Setting up and operation of the factory;

(d) Provision of documentation relating to product design, production process, software, etc.;

(e) Training of personnel;

(f) Installation and commissioning of the exchange;

(g) After-sale logistic services;

(h) Establishment, ultimately, of a local R&D capability.

The financial aspects of the manufacturing operation were analyzed for the two plant capacities (i.e. 250,000 and 500,000 exchange lines). Since certain costs are influenced by plant location which cannot be determined prior to the feasibility study, two groups of countries, each with similar economic conditions (e.g. wages and construction costs) are analyzed to a degree compatible with the level of this study. Group I includes those ECWA countries which export oil while Group II consists of those which do not. The results are shown in the following table:

Summary Decision Matrix for Telephone Exchange Factories

Item No.	Description	Group I		Group II	
		250,000 (lines)	500,000 (lines)	250,000 (lines)	500,000 (lines)
1.	Total fixed capital, all equity basis (millions of US dollars)	85	143	80	135
2.	Working capital, assumed short borrowing (millions of US dollars)	24	47	23	45
3.	Number of persons employed	1 070	1 704	1 070	1 704
4.	Payback period (years)	4.4	3.5	3.7	3.1
5.	Average undiscounted rate of return over 10 years period on total cash (percentage per annum)	18.2	26.0	24.7	33.3
6.	Internal rate of return	12.9	16.1	15.5	18.6
7.	Unit cost of production (US dollars)	334	319	316	305

Source: Joint ECWA/UNIDO Industry Division.

Conclusions

(a) A telephone exchange factory with an annual output of 250,000 lines, would be economically feasible;

(b) The cost structure is only slightly elastic with respect to production output or plant location. This is attributed to the high share of material cost in the total cost of production;

(c) It would be possible to set up factories in different subregions of ECWA, which would stimulate balanced regional industrial development. The projected regional market would be able to absorb the output of three factories (each with a capacity of 250,000 exchange lines) during the period 1986-1990, and the output of a fourth factory during the following five years;

(d) A number of other telecommunication products whose expected growth would not seem to justify separate manufacturing plants could be manufactured in the telephone exchange factory. They would include branch exchanges, multiplex equipment, signalling adaptors and other electronic equipment. Despite similarities in the hardware of telex exchanges and telephone exchanges, telex exchanges have not been included because their software is expensive to produce.

1.3 Pre-feasibility of manufacturing telephone instruments - summary of ECWA study 1/

The manufacturing data on which the study is based pertain to the conventinal disc dial instrument. However, it is proposed that the following features be incorporated in the instruments to be produced in the region:

(a) Push-button or touch-button dialling because of its advantages in signalling, especially in conjunction with digital exchanges which represent the trend for the future;

(b) Miniaturized electronic integrated circuits instead of discrete electronic components;

(c) Electromagnetic microphones instead of carbon microphones, because of their higher efficiency.

Three plant capacities were analyzed: 50,000, 100,000, and 150,000 instruments. In all cases the level of integration was assumed to be the same. Thus, all plastic and metal parts would be fabricated in the factory. Likewise the manufacture of cords (assembly manufacture) would also be done locally. The factory would procure the cordage, bare printed circuit boards (possibly from the telephone exchange factory), electronic components and magnets specialized suppliers. This would seem to be a realistic level of integration and local production could be expected to exceed 50 per cent of all production.

Full capacity could be reached within four years for 50,000 instruments, and within five years for 100,000 and 150,000 instruments.

1/ ECWA. Joint ECWA/UNIDO Industry Division, The Viability of Establishing a Regional Telecommunication Industry in the ECWA region, Pre-feasibility Study on Telephone Instruments, (volume I), part 3, Development of Selected Industrial Branches, No.2, 1985.

In all cases, the pre-production (construction) phase is assumed to be two years.

Except for the manufacture of the parts described in the previous paragraph the manufacture of telephone instruments is relatively simple, consisting of simple assembly and testing operations most of which could be labour-intensive. It does not require foreign technical assistance, and most of the skills it requires are available in the region.

The financial aspects of the manufacturing operation were analyzed for the three plant capacities and for the oil-exporting countries group I, and the non-oil exporting countries group II. The results are shown in the following table.

Summary Decision Matrix for 50 Thousand, 100 Thousand, and 150 Thousand
Telephone Instruments Factories

Item		Group I			Group II		
No.	Description	50 000 Instruments	100 000 Instruments	150 000 Instruments	50 000 Instruments	100 000 Instruments	150 000 Instruments
1.	Total fixed capital, all equity basis (millions of US dollars)	2.7	3.6	4.3	2.4	3.3	3.9
2.	Working capital, assumed short borrowing (millions of US dollars)	0.4	0.8	1.1	0.4	0.7	1.1
3.	Number of persons employed	150	220	290	150	220	290
4.	Payback period (years)	Infinite	7.9	5.6	9.4	6.2	4.9
5.	Average undiscounted rate of return over 10 years period on total cash (percentage per annum)	Negative	6.2	14.0	1.7	10.7	17.9
6.	Internal rate of return	Negative	5.5	10.7	2.0	8.9	13.1
7.	Unit cost of production (US dollars)	31.2	27	25.4	29.9	26.1	25.0

<u>Source</u>: Joint ECWA/UNIDO Industry Division

Conclusions

(a) At the assumed level of integration, a plant capacity of less than 150,000 instruments is not recommended. Since only the markets of Iraq, Kuwait and Saudi Arabia could individually absorb the output of such a plant, telephone instruments might be considered for regional manufacture;

(b) On the other hand, because such an operation would make little contribution to the transfer of technology to the region and because the standardization requirements and necessary investment would be relatively low compared with other telecommunication products, assembly-type operations at smaller plant capacities (e.g. 50,000 instruments) might be found to be economically viable, and consequently telephone instruments could be produced at the national or subregional level as is done at present;

(c) The only justification for manufacturing this product on a regional basis would be to maximize the local manufacture of its components. This could be a central activity feeding assembly-type operations at the national level.

1.4 Summary of discussions

There was unanimous agreement that the studies formed an adequate basis for evaluating candidate regional projects and for outlining steps towards their implementation. The following areas of concern were discussed by the group of experts.

How can these projects be properly presented to the decision-makers? This item would be discussed further during the session.

There was some concern that the related technology was advancing very rapidly. This concern, however, represented a challenge and an opportunity to develop to a standard equal to that of the major companies. Those companies had large investments in facilities and equipment which might soon be outmoded and therefore, they were very likely to want to get rid of them. It was generally agreed that the adopted projects should make use of the latest in digital technology.

It was considered important to ensure that there were adequate skilled manpower and training facilities. It was noted that it takes time to absorb the new technologies. There was some concern regarding the boundaries and the cost of transportation between the different countries. However, it was assumed that ultimately agreements would be made between the countries of the region to facilitate trade in such products. Further, the cost of transportation is becoming less significant since the size and weight of these products are becoming smaller and the products are being constructed in modules.

There was some concern that the manufacturing companies which possess the technologies are monopolistic and might not be easily persuaded to sell their expertise, especially as it might be to their advantage to sell those facilities which are becoming obsolete. Therefore, it was stressed that, before they buy, the countries should know what they want and acquire their own expertise to guide them in purchasing the required facilities and services.

It was considered by some more desirable to recommend a plant capacity of 500,000 lines per year for the digital exchange project rather than 250,000 lines per year. It was further emphasized that since the study showed profitability at 250,000 lines per year, it would be natural to assume that it would be even more profitable at 500,000 lines per year, especially as the market could support the increase in capacity.

It was acknowledged that the estimate of required manpower (i.e. 1,700) seemed to be rather high, but it was pointed out that this figure was inflated to take into account the lack of trained personnel and possible turnover in personnel. In spite of this inflated manpower requirement, the study showed that the project could still be viable.

The projections were considered to be conservative. This was acknowledged, and it was pointed out that, in fact, the market size could support many communication industries and the telephone exchange and other projects should be viewed as possible catalysts for developing further projects in the telecommunications industry.

The costs in the report were based on 1980 estimates that were supplied by international manufacturers and consulting firms in the construction field. The impact of inflation and other factors which increases costs should be taken into consideration when presenting such a cost analysis to the decision-makers. This was acknowledged, but the great difficulty of accurately projecting the rates of inflation especially during the next five years was stressed.

It was noted that the projects identified in the study were not only an extremely important part in the chain of transfer of technology, but also a stimulus to related industries such as the manufacture of electronic components and other electronic products such as entertainment products and and industrial instrumentation.

One important area of concern was how to implement the conclusions of these studies and the deliberations of the experts and how to have them accepted by the decision-makers in the countries concerned. It was suggested that the Arab Industrial Investment Company and/or other regional investment companies should be invited to carry out the next steps towards financing and implementation.

In general, it was agreed that:

(a) The digital telephone exchange system should be a priority product for regional co-operation, and the project should be implemented as soon as possible;

(b) Telephone instruments projects could be implemented on a national or subregional level. The capacity of each industry in these countries could be increased to cover markets beyond their boundaries. Telephone instruments would not be particularly suitable for regional manufacture because their technology is not at the level of the technologies of other products selected for regional manufacture. Since the emphasis is to acquire up-to-date technology of a high standard, such as in the telephone exchange, the low level simple technology of telephone instruments is not compatible in that sense.

B. Cables manufacturing

1.5 Telephone cables - summary of ECWA study1/

Underground telephone cables are the most expensive components in telecommunications development in any country, representing 15 to 20 per cent of the total cost. With the massive programmes of telecommunications development in ECWA member countries, large quantities of cables are required. The manufacturing capacities established so far in the region cannot satisfy even a small part of the total demand and therefore most cables are imported.

The manufacturing technology for telephone cables is not complex, nor are the skills required on the shop floor particularly demanding. However, material and production management skills of a high standard are needed. Some of the raw materials like polyethylene and polyvinylchloride will be available within the region.

Demand for telephone cables for local networks is determined by the number of direct exchange lines added in a particular period, while the demand for trunk network cables depends upon programmes for the establishment of inter-district and international communication links. The demand for trunk network cables is also determined by the systems on which the trunk links are based. These include open wire systems, coaxial cable systems, microwave systems, radio links, satellite systems, etc. The development of systems based on the use of fibre optics is also at an advanced stage of development. Programmes of ECWA member countries for trunk network development are still unclear. However, forecasts of future additions of direct exchange lines in the region have already been made. It is quite logical, therefore, to concentrate at present on the cables for local networks.

Based on comparative data from different sources, as elaborated in the ECWA study, it is concluded that 5,400 to 6,000 circuit metres of cables are required for every direct exchange line. During the initial periods of telephone network development, the requirements for cables are higher than in the later periods due to the fact that provisions for expansion and flexibility are made in the initial periods. Based on the

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1/ ECWA/UNIDO Industry Division, Establishment of Telephone Cables Industry in ECWA Region, a Techno-Economic Study, (volume 1), part 4, Development of Selected Industrial Branches No. 2, 1985.

projections of addition of direct exchange lines in the ECWA region and the norms of requirements of cables for different periods, the estimated summary of demand has been given below:

Summary of Demand Estimates for Telephone Cables for ECWA Region

Period	Projected annual average addition of direct exchange lines (DELS)	Requirement of TF cables per DEL (circuit metres)	Estimated average annual demand (SKM)*
1976-80	361 500	6 000	21 690
1981-85	433 500	5 800	25 143
1986-90	791 000	5 600	44 296
1991-95	981 000	5 400	52 774

* SKM = 100,000 circuit metres or one KM of 100 circuit cable.

Demand for different sizes and types of cables will depend upon the requirements of the different networks which have been custom-designed to suit local needs. The plants to be built in the future should be flexible enough to manufacture a wide range of cables to meet the needs for the whole region.

Accurate date on details of existing and planned manufacturing facilities in the region are not available. According to available data, Egypt has a facility to manufacture telephone cables with a reported annual capacity of 5,900 tons, as a part of a large cable manufacturing plant with an overall production capacity of about 33,000 tons of various types of cables and wires. Assuming conservatively that the Egyptian plant is manufacturing cables of the lighter varieties and that the ratio of capacity in terms of SKM to that in weight is about 2.3 instead of usual 1.2, the capacity of the plant can be reckoned at 4,000 SKM per year. This plant has been operating in the past at levels much below its rated capacity. The reasons for this under-utilization of capacity are not known. Iraq is reported to be currently implementing as the second phase of a large cable manufacturing complex, a project for 3,000 SKM or 6,000 tons annual production capacity for telephone cables. The production programme of this phase also includes winding wires. Capacities of plants in Syria and Lebanon appear to be negligible. It is reported that facilities for manufacturing telephone cables as part of plants with a wider product mix, including power cables, are being built in Kuwait and Saudi Arabia, but the details are not available.

Technology for the manufacture of telephone cables for local networks is of lower middle-range complexity and no difficulties are envisaged in regard to its absorption. Depending on the type of cable to be manufactured different combinations of the following operations are used:

(a) Pickling
(b) Wire rolling
(c) Wire drawing
(d) Bright annealing
(e) Paper insulation by wrapping
(f) Insulation coating (PE)
(g) Plastic extrusion
(h) Lead extrusion
(i) Metal sheathing
(j) Core assembly
(k) Armouring
(l) Serving
(m) Impregnation and drying

The production equipment is generally flexible enough to be able to manufacture a wide variety of cables.

The main raw materials and the intermediates which are used to manufacture telephone cables include:

(a) Electrolytic refined copper rods
(b) Polyethylene compounds
(c) Polyvinyl compounds
(d) Insulation paper
(e) Copper tape
(f) Aluminum tape
(g) Armour wire and tape
(h) Cotton tape, jute, bitumen, oil, etc.
(i) Timber for making cable drums

Economic conditions which govern the viability of industrial projects vary from one ECWA member country to another, suggesting that the sizes of minimum economic plants should be different in different countries. Within a particular country, economies of scale may be affected by different sites. This makes the problem of size and location complex. Nevertheless, the region can be divided into two groups, based on certain similar economic conditions:

Group I: Bahrain, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates

Group II: Egypt, Iraq, Jordan, Lebanon, Syria.

Within the groups, there is a fair degree of homogeneity in wage levels and construction costs.

Plant sizes of less than 10,000 SKM annual capacity will not be economical in any of the groups. Analysis of operational economics of 10,000 SKM and 20,000 SKM annual capacity plants for the two groups gives the following decision matrix for arriving at the most appropriate plant sizes.

Summary Decision Matrix (SKM)

No.	Item Description	Group I		Group II	
		10 000	20 000	10 000	2 000
1.	Total fixed capital (all equity basis)(thousands of US dollars)	37 920	67 851	34 205	61 634
2.	Working capital (assumed as short borrowing)	10 470	20 100	9 910	19 100
3.	No. of persons employed	690	1 222	690	1 222
4.	Payback period (years)	7.13	4.97	4.70	3.71
5.	Average non-discounted rate of return over 10-years-period on total (percentage per annum) fixed capital	7.17	15.22	16.45	24.43
6.	Internal rate of return (percentage per annum)	6.49	11.57	11.81	16.16

A plant to be established in group I should have a capacity of 20,000 SKM per annum while for group II it could be 10,000 SKM. Both alternatives will give an internal rate of return of about 12 per cent per annum. Payback periods in these alternatives would also be quite reasonable. A plant with an annual capacity of 20,000 SKM in group II, even though it had the highest profitability among the four alternatives, would not be suitable, as it would upset the balance which can be achieved through the other two preferred alternatives.

If the plants should be of the sizes selected above, and after accounting for existing and already planned capacities and in the case of annual demand supply gap being of the order of 10,000 SKM, then a plant of this capacity should be established in group II. If the gap is around 20,000 SKM a plant in group I will be more advantageous as the existing capacities are located in group II. In all cases, provisions for expansion should be made in order to keep the enterprises economical in the future.

The demand figures given above represent averages during particular five-year periods. For the purpose of outlining a strategy for the development of the telephone cable industry, it is necessary to have yearly demand figures. Assuming an arithmetical growth of demand during the period under consideration and based on the average figures of demand as estimated earlier, projected demand, for selected years, can be summarized as below:

Moderated Average Annual Demand (SKM)

Year	Total	Group I	Group II
1983	25 143	13 775	11 368
1985	30 709	17 532	13 177
1987	36 276	21 290	14 986
1989	41 841	25 047	16 794
1991	47 407	28 805	18 602
1993	52 974	32 562	20 412
1995	58 540	36 319	22 221

From the present indications it appears that the plant in Iraq will be operating by the end of 1983 and will be able to produce to its full capacity of 3,000 SKM in 1985. In addition, the possible supply of 4,000 SKM from the Egyptian plant will make total supply in 1985, from existing and planned facilities, at 7,000 SKM against a demand of 30,709 SKM. Establishment of a plant with an annual capacity of 20,000 SKM in group I, which should also be able to achieve nearly full production in 1985, is justified. In 1983, steps should be taken to establish another plant in group II with an annual capacity of 10,000 SKM. Thereafter, expansion of the existing plants and those recently proposed for group I and group II can be undertaken after they have individually reached their full capacity and have acquired the necessary skills.

The above approach will give the following supply/demand balance:

Summary Demand/Supply Balance (Figures in SKM)

Year	Total for the Region		Group I		Group II	
	Demand	Supply	Demand	Supply	Demand	Supply
1985	30 709	25 000	17 532	18 000	13 177	7 000
1990	44 625	41 200	26 925	20 000	17 700	21 200
1995	58 540	54 000	36 319	25 000	22 221	29 000

The latest development in the field of telecommunications has been the use of glass fibres as the transmission media instead of copper cables. A considerable amount of research and field trials has already been conducted. A reasonable measure of success has been achieved in medium and long-distance transmission of sound signals through glass fibre cables using lasers. However, it is unlikely that fibre glass cables could economically replace copper cables in local networks in the foreseeable future.

1.6 Power cables - summary of ECWA study[1/]

Given the massive electrification programmes undertaken in the countries of the ECWA region, the need for generating an indigenous supply of cables from local sources was recognized and many production units in Kuwait, Saudi Arabia, the United Arab Emirates, Egypt, Iraq and Syria were established for the production of power cables. Most of the units are, however, now manufacturing low-tension power cables. Such an accelerated growth calls for co-operation at regional level so as to avoid duplication and excess capacities. The demand for high-tension cables, in spite of accelerated growth of the cable industry is still, by and large, being met through imports.

Demand for power cables is a function of the addition to annual capacity demand in million kw. Based on comparative data from developed European and developing Asian countries, and having regard to the developments in the ECWA region, a figure of 15,000 km/million kw of capacity has been taken as a norm for estimating the demand. Out of this, 5,250 kms will be MV and HV cables.

On the above basis, the future demand for MV/HV power cables has been estimated as follows:

Summary of Demand Estimates for MV/HV Power Cables
for ECWA Region

	Projected annual average addition to generation capacity (GW)	Average annual requirements of cables (km)
1981-85	2.540	13 336
1986-90	4.579	24 040
1991-95	4.707	24 712
1996-2000	7.384	38 765

1/ ECWA/UNIDO Industry Division, Establishment of Power Cables Manufacturing Industry in the ECWA Region: A Techno-Economic Study, 1980

The demand for various sizes and types of cables will depend on their proposed voltage and duty characteristics. However, in line with the latest practices, cross-linked polyethylene (XLPE) insulated cables are recommended for manufacture in the 3.3 kV to 33 kV range. Cross-linked PE insulated cables can be used even at higher voltages. However, the study does not cover the higher voltage cables which are required in much smaller quantity.

Data on capacity, range and actual production by various existing units in the region are not readily available. The plant in Egypt is apparently under-utilized. New units are planned or were at different levels of implementation in Kuwait, the United Arab Emirates, Saudi Arabia, Syria and Iraq. Lebanon also has a small unit. More detailed information is needed on existing and recently planned units so that their possible contribution to meet the regional demand for HV and MV cables can be better assessed.

Technology for the manufacture of the proposed XLPE insulated power cables is of medium complexity and with proper equipment no difficulty is foreseen with regard to its transfer or its absorption.

The following are the usual processes/operations involved: copper rod pickling and wire drawing, bright annealing of copper and in-air annealing of aluminium, wire-stranding, extrusion of semi-conductive/XLPE insulation, semi-conductive screening layer, vulcanizing by dry curing (RCPV) process, copper taping, corelying with PVC-fillers and PVC tape, wrapping, steel wire/tape armouring, bedding with pre-tape, overall PVC sheathing, packing by winding on to wooden or steel drums.

Proper storage of incoming raw materials, continuous, stage-by-stage, inspection and built-in devices for quality control will obviate rejects in the finished cable testing. Accelerated performance tests like high voltage tests, short circuit tests, aging tests, etc. are expected to prove and guarantee the longevity of the product.

The main raw materials for the manufacture of XLPE insulated armoured power cables 3.2-33 kV and the intermediate include: electrolytic quality aluminium rod, or copper rod, semi-conducting XLPE compounds, XLPE insulation, copper tape for shielding, PVC fillers and bedding tape, galvanized steel wire or cold rolled steel tape, PVC sheath, wooden steel drums and semi-conducting textile tape.

The economic viability of industrial projects varies among ECWA member countries suggesting that the sizes of minimum economic plants should be different in different countries. Within a particular country economies of scale may be affected by different sites. This makes the problem of size and location complex. However, in the ECWA region, the similarities of economic conditions among the different countries do exist to the extent that for the purpose of a preliminary analysis of viability, the region can be divided into two sets of countries namely Gulf (high cost) and non-Gulf (low cost).

Plant sizes of less than 1,200 km would not be economic in any of the countries. Analysis of operational economies is given in the decision matrix table below. These decision indicators correspond to the ratio of raw materials cost to sales price of 55 per cent.

Decision Matrix Table

Item	Description	Gulf Countries			Non-Gulf Countries		
		3,600 kms	2,400 kms	1,200 kms	3,600 Kms	2,400 kms	1,200 kms
1.	Total fixed capital (all equity basis (thousands of US dollars)	45 023	33 420	22 110	41 825	30 925	20 110
2.	Total fixed capital (with long-term loans (thousands of US dollars)	47 300	35 100	23 200	44 000	32 500	21 100
	Out of which: Equity	24 300	18 100	12 200	22 000	16 500	11 100
	Loan	23 000	17 000	11 000	22 000	16 000	10 000
3.	Working capital (assumed as short borrowing (thousands of US dollars)	28 000	18 700	9 500	27 700	18 500	9 400
4.	Number of persons employed	188	129	99	188	129	99
5.	Payback period (years)	1.50	1.70	2.25	1.40	1.60	2.00

It has been found that the plants would be viable and profitable at the annual capacities of 2,400 km and 3,600 km. However, in view of the international pricing arrangements by manufacturers of cables, sensitivity of profitability to the raw material price ratio has been worked out in the ECWA study.

Strategy suggested: The first objective of a plan to develop the industry should be the utilization of existing investments in an optimal manner to be followed by the creation of new capacities to satisfy the regional demand. The existing cable manufacturing plants in Egypt, Iraq, Kuwait, Lebanon, Syria, Saudi Arabia and the United Arab Emirates may, in order to improve their production economies and to cover their national markets, add XLPE cables manufacturing lines in the immediate future. However, their expansion programmes should be formulated and carried out after studying the following areas:

(a) Assessing the potential of the individual units for modernization, production line balancing and expansion;

(b) Rationalizing their product mix with a view to reducing, individually, their product range in order to derive the advantages of specialization given the opportunities offered by the regional market;

(c) Assessing their potential, individually, to satisfy their country's internal demand and then their possible contribution to the regional supply with regard to individual types of cables.

It is obvious that, at present, in the absence of detailed reliable information on existing and planned units, it is not possible to formulate concrete recommendations. However, assuming that all these units would be expanded to the maximum extent in the shortest possible time - an assumption which is conservative while planning new industrial units - the following supply position would emerge at the end of various years:

1985 - 10,800 km of XLPE cables per year or in other words eight additional lines each with an annual capacity of 1,200 km would be installed during 1981 - 1985.1/

1990 - 15,600 km of XLPE cables per year or in other words 12 XLPE lines each with an annual capacity of 1,200 km.

Gaps after these expansions would have to be bridged by establishing new specialized production as follows:

1981 - 1985: A plant with an annual capacity of 2,400 kw.

1/ Assuming the line capacity is the only existing XLPE plant, i.e. in Kuwait, to be 1,200 km per year.

1986 - 1990: Two additional plants, one with an annual capacity of 3,600 kw and the other 2,400 kw.

Most of the raw materials for XLPE manufacture would be available from within the region. Aluminium rod would be available from an existing plant in Bahrain and from aluminium plants planned for construction in other parts of the Gulf. Copper deposits in Oman and Saudi Arabia are being studied with a view to establishing copper smelting and refining projects. Polyethylene is already available in plentiful supply. Cross-linking compounds and minor materials would have to be imported. However, the share of such imported materials in the cost of production would be very low.

A special market mechanism is needed for regional co-operation. The world power cable export market is, to a large extent, controlled by the International Cable Development Corporation (ICDC) with its headquarters in London. The major cable manufacturers in various countries have formed themselves into national associations and these associations are in turn members of the International Corporation. In most cases, the governments of the respective countries have also supported and encouraged such international marketing co-operation in the interests of their country's own export trade. The individual national associations have also set guidelines for, and generally control, the internal pricing of various types of cables and wires. In most cases, they have also resorted to the quota system in allocating public tenders of $US 100,000 or more to various members, fixing ceiling prices to be quoted by the member to whom the business is allocated and suggesting floor prices which the non-allottees should quote to protect the allottee.

Therefore, these ECWA member countries which intend setting up cable factories to produce power and telecommunication cables should consider introducing a certain amount of internal and regional pricing co-operation both for the local and the export market. Moreover, the governments of the region should be prepared to give financial assistance and protection to the indigenous industry, i.e. protective import duty for finished cables and financial assistance for exports of such cables.

1.7 Summary of Discussions

The experts expressed their satisfaction in the thoroughness and completeness of the studies presented. Some were very pleased about the methodology and freshness of ideas and approach.

It was stated that the findings of the study on copper cables for an internal telephone network should help the decision-makers in the ECWA region seriously to consider the implementation of such projects.

It was proposed that a plant with a capacity of 20,000 SKM could be built in the Gulf region. Another plant of 10,000 SKM could be located in another part of the ECWA region.

The manufacture of fittings in one of the two plants should be considered. In case further studies do not justify the establishment of facilities for the manufacture of fittings, long-term agreements with some foreign suppliers should be made in order to ensure the continuous availability of a fittings uniform standard.

The implementation of new cable projects as well as existing projects of a similar nature might justify the establishment of a copper-refining facility. This might be one of the candidate projects to be included in the ECWA future work programme.

With regard to the manufacture of coaxial cables and the increasing demand for such cables, further studies might have to be undertaken at the time of conducting the feasibility study for cables.

Some participants remarked that the studies lacked information on existing facilities for the manufacture of power cables and, therefore, no detailed and definite conclusions could be made. It was pointed out that the main obstacle faced by ECWA in preparing the studies was the lack of accurate and up-to-date information. In this respect, certain recommendations should be made to member governments and relevant organizations to help ECWA to have easy access to information in the region.

Co-ordination between existing and future plants is important in order to achieve specialization of each plant with respect to certain products, thus improving performance.

One expert commented on the parameters used in the financial analysis, pointing out that the figures relating to the cost of buildings, erection, technology and interest on borrowings which were used in the studies were rather low. It was suggested that the financial analysis be revised using accepted current prices. The secretariat pointed out that the cost figures used in the study referred to 1979 and were obtained from reliable consultants and contractors in the region and that similar figures have been used in other studies. Further, if the analysis were revised to reflect the present cost levels, then it might be necessary to revise it again, by the time the the investment decision is taken. It was further stated that the objective of the study, at this stage, was to propose candidate projects; therefore, the accuracy of estimate expected from the studies might have an error margin of ± 25 per cent as accords with international practices. In future, and as far as is possible, sensitivity analysis will be included in the studies. This would help in revealing the effect of price fluctuations on the viability of the projects.

The importance of raw materials to the industry was discussed. The fluctuating price of copper in the world market and the absence of production facilities of this material in the region were considered a handicap. On the other hand, the expected availability of complementary products originating from the petro-chemical projects, which are being established in the region, should benefit the cables industry.

It was pointed out that copper deposits have been discovered in several countries of the region, such as Saudi Arabia, Oman, Yemen and Democratic Yemen. Some studies have already been embarked upon to explore the possibility of establishing smelting facilities. In this respect, it was mentioned that a study of the basic metals industry including copper in the region is included in the future programme work of the ECWA/UNIDO Industry Division.

The effect of the continuous supply of dies to the industry was discussed and the painful experience of one country in the region was mentioned. Therefore, it was suggested that facilities for making dies be incorporated in the proposed plant. It was pointed out that making dies for this industry was not particularly complicated and that it might be taken up with captive too-room facilities. However, well-equipped specialized tool-rooms should be established in the countries because they are a necessary part of the basic infrastructure for the engineering industry.

Owing to fluctuations in the price of copper and the absence of copper in the region, the use of aluminium instead of copper was discussed. Because of high energy costs, the cost of aluminium was approaching that of copper. A part from the cost factor, it was pointed out that copper has certain superior properties and that there are difficulties involved in using aluminium in telephone cables and in large-size power cables.

The question of excess capacities in some developing countries and their influence on the proposed industry were brought up. However, it was pointed out that the energy crisis had resulted in an increase in the establishment of hydro-projects and thermal projects throughout the world, stimulating demand for power cables.

It was pointed out that in many countries, the manufacture of cables is highly automated and, therefore, doubt was expressed as to whether a 10,000 SKM capacity plant would be feasible.

Optical fibre cables should be considered from the operational point of view only when a wide band was required. This might limit the application of optical fibre cables to connect exchanges. The durability of conventional copper cables for internal network was pointed out. Owing to these factors, the proposed plants would not be likely to suffer from technological obsolescence. The close-circuit nature of optical fibre technology was mentioned and it was thought that it might not be possible to acquire it in the foreseeable future.

The importance of training as well as Research and Development to the industry was thoroughly discussed. Some experts pointed out that investment related to training as well as the establishment of training centres would have to be incorporated within the project in order to give a complete picture of economic viability. However, other experts were of the opinion that training in developing countries should be considered as part of the basic infrastructure so that expenditure in this regard should be borne by the Governments. The industry should not be overburdened with training and research and development costs.

The Group noted with approval the approach adopted in the studies to consider planning acquisition development and the adaptation of technology thoroughly at the initial stage. The experience of Mexico, with its ambitious programme in capital goods, was cited. There, the questions relating to development and adaptation of technology were deferred to a later phase of the project's implementation and consequently many difficulties were encountered.

The Group concluded that the development of telephone cable manufacture be considered at a regional level while there should be active co-operation amongst existing manufacturers in the case of power cables. The market requirements for high voltage cable should be met preferably through the addition of XLPE production to the existing manufacturing plants as suggested in the studies.

It was pointed out that the cable industry deserves immediate attention in regard to standardization.

C. Chemical process equipment manufacturing

1.8 Summary of ECWA study [1/]

In line with the basic objective of optimizing the use of natural hydrocarbons deposits, the countries of the ECWA region have launched massive programmes for the establishment of hydrocarbon-based industrial projects. New oil refineries, petro-chemical projects, fertilizer units and gas extraction and processing units are being established in the region in order to derive the maximum benefits. To accelerate development, these industrial branches have relied on foreign sources for supply of capital equipmment and technologies which have greatly increased the cost of these projects. Capital equipment accounts for the largest part of the cost of chemical industry projects. Out of the many categories of equipment used in the chemical industry, fabricated static equipment, which includes process vessels, reactors, chemical furnaces, heat exchangers, storage vessels, etc., is the largest component both in terms of money-value and weight. The manufacture of such equipment entails the use of general-purpose engineering manufacturing facilities and skills which can also be used for the manufacture of capital equipment for other industries. The establishment of these general-purpose manufacturing facilities is fundamental to the development of engineering industries in general. This study presents an analysis of the prospects of establishing industrial units to manufacture

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1/ Joint ECWA/UNIDO Industry Division, Establishment of Manufacturing Capacities for Fabricated Equipment for Chemical Industries in the ECWA Region, A Techno-Economic Study, (volume II).

fabricated static chemical equipment; it also examines the viability of such units and elaborates the crucial technical and economic factors associated with the establishment and operation of such units.

End-use industries for fabricated static equipment

Owing to their versatile nature, fabricated static chemical equipment manufacturing units can cover a very wide range of products which can be used for hydrocarbon industries, chemical industries, food industries, power generation (nuclear reactors, power boilers, etc.) mineral-processing industries, drugs and pharmaceutical industries, etc. However, the hydrocarbon-based industries are of greater importance to the ECWA region and, therefore, emphasis should be placed, at least initially, on the development of capital goods manufacturing capacities which will satisfy the requirements of these industries. Accordingly, applying the rule of exception, while analysing the demand, the end-use industries are limited to:

(a) Oil-refining;
(b) Petrochemical industries;
(c) Fertilizer industries;
(d) Gas extraction and processing.

The oil-refining industry started in the ECWA region in Bahrain, Egypt, Iraq, Kuwait and Saudi Arabia. Currently, there are 31 refineries operating in the region with a total capacity of approximately 3 million barrels per day with individual capacities ranging from 6,000 b/d to 565,000 b/d. There are 11 large refineries, each with capacities of 100,000 b/d or more. Most of the large and medium refineries have either modern diverse facilities like hydro-cracking and catalytic-cracking units or have plans to establish such facilities. With the expansion plans for the oil-refining industry under way, the total oil-refining capacity in the region is expected to be 4.6 million b/d by the year 1990.

Petrochemical industry

During the last decade, the countries of the region have been investing heavily in the establishment of a petrochemical industry. Iraq, Qatar, Saudi Arabia, Kuwait, Bahrain and Egypt are the countries which have developed capacities for production of a variety of bulk petrochemicals. The products of the industry include polyethylene, polyvinyl chloride, ethylene glycol, styrene, ethanol, DMT P-xylene, O-xylene, heavy aromatics etc. The known projects give the following overall capacities:

Capacities of Production of Petrochemical Products Through Known Projects in ECWA Region (In thousands of tons/year)

	Present (1979)	Additions During 1980-85	Additions During 1986-90
Ammonia	2 164	2 751	2 310
Urea	2 585	2 340	1 955
Methanol	-	-	1 530
Ethylene	-	415	2 206
L D P E	-	290	920
H D P E	-	70	99
M V C	-	66	82
P V C	-	140	-
Ethylene Glycol	-	-	765
Ethylene Dichloride	-	-	454
Styrene	-	-	615
Polystyrene	-	10	-
D M T	25	-	-
Cracked Naphtha	-	-	300
Benzene	-	-	284
Heavy Aromatics	-	-	30
O-xylene	-	-	60
P-xylene	40	-	86

The development of the petrochemical industry is likely to continue, at least at the present rate, due to inherent advantages of proximity to the raw materials and the availability of funds for investment. However, the future composition of the product mix of the industry in the region cannot be predicted in this study. This is a matter for a separate detailed study.

Fertilizer industry

Most of the countries in the region, with the exception of Yemen, Democratic Yemen and Oman, have established or are in the process of establishing their capacities in fertilizer industries, including ammonia and urea. Jordan, Syria and Iraq have good deposits of phosphate rock. Jordan is establishing a project for the recovery of potash from the Dead Sea. Expansion of the nitrogenous-fertilizers industry will continue because of the ready availability of hydrocarbons. Expansion in the production of phosphatic and potash fertilizers will depend upon discoveries of new deposits. The following summarizes the capacities as derived from the known projects.

Fertilizer Capacities in ECWA Region
(In thousands of tons)

	Present (1979)	Additions During 1980-85	Additions During 1986-90
Ammonium phosphate	-	398	100
Sulphuric acid	978	3 650	-
Phosphoric acid	99	1 025	-
D A P	-	740	-
Potash	-	1 200	-
S A P	-	250	-
Nitric acid	1 084	15	-
Calcium ammonium nitrate	1 277	587	-
Phosphates (32-34 %) nitrates	2 500	2 500	-
T S P	300	1 250	-
S S P	746	510	-
N P K	100	272	-

Gas processing industry

ECWA countries are currently in the process of reviewing their policy on utilization of associated and dry gas deposits. Prior to 1973, most of the associated gas was being flared. The current projects are mostly geared to the utilization of gas for power generation, as feed-stock for petro-chemicals and to meet the local demand. These projects, however, barely touch the surface of the associated-gas problem and plans for the development of the area are not yet clear.

Demand for fabricated equipment

According to the surveys conducted by the Hydrocarbon-Processing Journal in 1978, the cost breakdown of equipment installed within the battery limits is as follows:

		Percentage
(a)	Fabricated static equipment (vessels, furnaces, heat exchangers etc.)	37
(b)	Dynamic mechanical equipment (pumps, compressors, turbines etc.)	13.5
(c)	Supplies (pipework, valves)	16
(d)	Instrumentation	7
(e)	Electricals	6
(f)	Others	20.5

Due to the heavy cost of fabricated static equipment in the total requirements and the fact that the skill in fabricated static equipment manufacture can be built up faster than in dynamic mechanical equipment manufacture, the present analysis is limited to fabricated static equipment. Manufacture of electrical equipment and instrumentation has to be considered when an analysis of demand for such products for other sectors is also made.

In order to assess the demand for fabricated static equipment in the oil-refining industry, a refinery with a through put capacity of 100,000 b/d and facilities such as a vacuum flash unit, unifiner plate formers, viz, breaker, isomax, etc. was taken as the model and the following estimate for equipment in the model refinery was made:

Process vessels	3,328 tons
Heat exchangers	2,132 tons
Furnaces	1,805 tons
Storage vessels	13,750 tons

Next, multipliers were calculated by the capacity exponential method using 0.65 exponential for each of the oil refinery projects in the region. These multipliers represent, as equivalent of each refinery to the model refinery in terms of category, equipment requirements. Applying these multipliers to the norms for the model refinery, the equipment required for each refinery was computed and them aggregated. It was possible to estimate the demand, based on the known projects, up to the year 1990. For the period 1990 to 2000, the same level of demand as in 1980-1985 has been assumed.

In the case of the petrochemical industry, norms of requirements of equipment per million US dollars of investment according to mid-1976 conditions in Europe were derived through aggregation of the requirments of a sample package of petrochemical projects and then divided by their total investment. The basic data pertaining to the equipment requirements were obtained from a study conducted by UNIDO for a country in the Middle East. These requirements per million US dollars of investment, according to European conditions, work out as follows:

Process vessels	18.0 tons
Heat exchangers	13.0 tons
Storage vessels	19.3 tons
Furnaces	7.6 tons

For each of the identified petrochemical projects, equivalent weighted investment according to the European conditions of mid-1976 was calculated by the exponential method using well-known exponentials for each of the petrochemical plants. The aggregated investment against each petrochemical product capacity was multiplied by the norms obtained above to arrive at the requirements of fabricated equipment for the petrochemical industry. As no information on development plans for the petrochemical industry for the period 1991-2000 is available, it has been assumed that the rate of petrochemical investments in this period will be the same as in 1986-1990.

The demand for fabricated equipment for ammonia and urea was included in the petrochemical group. The analysis for fertilizer industries was limited to the final fertilizer industry products, intermediates and reactants excluding urea and ammonia. The methodology used in this case was similar to that used for refineries but the following exponentials were used in estimating the demand:

Sulphuric acid Phosphoric acid	0.55
Phosphatic fertilizers	0.63
Nitric acid, ammonium Nitrate, calcium ammonium Nitrate.	0.63

According to the information available on the fertilizer industry, virtually no projects had been planned for the period beyond 1985, and except in the case of nitrogenous fertilizers, it was apparent that the scope of expansion of the industry was limited unless new deposits of potash and phosphates were located. Therefore, it was assumed that the level of demand for fabricated equipment during 1986-2000 would be 25 per cent of that during 1980-1986.

Until recently, most of the gases associated with oilfields in the region were being flared. The utilization of natural gas has now been limited. As pointed out earlier in this study, attempts are being made to rectify this situation. Individual member countries in the ECWA region are reportedly reviewing the situation and formulating new plans for effective utilization of the gaseous hydrocarbons. However, plans for development in this field are not clear enough to enable the ECWA/UNIDO Industry Division to make even very rough estimates of demand for equipment for gas extraction and processing industries in the region.

Just as this element of the demand should be considered in future detailed studies, also a modest allowance of 10 per cent of the demand for equipment for other end-uses namely, oil-refining, petrochemicals and fertilizer manufacture, should take into account the equipment demand for the gas-extraction and processing industry. This allowance would not in any way indicate actual demand.

The demand for fabricated static equipment is summarized below. The aggregated figures represent just a conjectural forecast of the future scope of the market. The demand will depend upon the plans of the ECWA countries with respect to the development of end-use industries.

Summary Estimates of Annual Demand for Fabricated Chemical Equipment in ECWA Countries (Figures in tons)

Category of equipment	1980-1985	1986-1990	1991-2000
Process vessels	13 500	22 500	22 200
Heat exchangers	9 200	15 100	15 600
Furnaces	6 300	9 000	9 700
Storage vessels	28 400	33 700	37 700
Total	57 400	80 300	85 200

Factors relating to marketability of fabricated static equipment

The process of marketing fabricated static equipment involves:

(a) The owner of the chemical project who is the investor and thus the ultimate purchaser;

(b) The process supplier who ensures the process guarantees and thus approves the equipment before purchasing;

(c) The contractor/engineer who has overall responsibility for the performance of the entire plant;

(d) The manufacturer who is responsible for the quality of mechanical design, materials of construction and workmanship;

(e) The standard institutes which are responsible for the technical pre-qualification of the manufacturer, his workmen, and the fabrication procedures;

(f) The inspection agency which ensures that the equipment conforms to agreed standards and specifications, and has been fabricated by approved workmen according to the approved fabrication procedures.

The strength of the enterprise engaged in manufacturing and marketing of fabricated static equipment should be determined by its ability to undertake erection work, its after sales service, its manufacturing and testing facilities, and the qualifications of its personnel. Location of the factory is an important factor which determines the ultimate cost to the customer. Owing to the weight and large dimensions of the products, the factory should be located near a navigable waterway, and it should have its own jetty facilities and also a railway yard if possible.

Owing to the very high degree of international competition in this field, and the length of time it takes to build skills and market acceptance, tariff and non-tariff protective measures should be taken by the governments of the region in order to avoid undue competition during the initial period. To market capital equipment successfully, the manufacturer should be able to offer deferred payment facilities. Therefore, refinancing facilities should be provided by the existing financial institutions in the ECWA region.

In order to be able to sell their products, the manufacturers of fabricated equipment have to be formally recognized, by the standards institutes and by engineering and contracting firms, as authorized manufacturers of code vessels. The basic requirements for such recognition are:

(a) A strong design team capable of designing pressure vessels according to the codes of practice;

(b) Elaborate, and well-documented manufacturing procedures;

(c) A team of welders qualified by a recognized welding institute or an inspection agency in accordance with relevant sections of the code;

(d) An elaborate inspection and quality control system duly set out in a manual which is approved by qualified accredited inspectors;

(e) Adequate destructive and non-destructive testing equipment.

Technology acquisition and development

The technology package should include:

(a) Project engineering and management;

(b) Design technology for products;

(c) Manufacturing technology;

(d) Operational management systems including documentation and assistance in marketing;

(e) Inspection and quality control methods;

(f) Erection procedures;

(g) Training.

The transfer of technology in all the above cases has to be effected according to the mandatory requirements set out in the codes relating to boiler and pressure vessels. These codes laydown the requirements and the procedures for acceptance of the design of vessels, the qualifications of personnel, inspection and quality control and minimum plant facilities. With regard to manufacturing technologies such as fabrication procedures, the manufacturers of the code vessels have to obtain approval through the accredited inspection agencies.

The technology transfer agreements should have built-in clauses for the continued inflow of the latest technologies. Therefore, before concluding such agreements, the purchaser of the technology should thoroughly evaluate the R&D activities currently being carried out in the world and ensure the inputs of the results of these activities into his enterprise. The agreements should also include options for the procurement of technologies relating to allied products such as cladded plates, bellows, titanium and zirconium castings, distillation and bubble trays, multi-wall vessels, finned tubes, etc.

The documentation to be acquired from the collaborations in the technology transfer process should also include the Welding Procedure Specifications (WPS), Procedure Qualification Records (PQRs), Quality Control Manuals and computer-based design software etc. which have already received the approval of the code-administering authorities. A regional welding institute should be also established to assist in the transfer of technology.

Unified codes for the manufacture of boiler and pressure vessels should be established for the region and one of the existing agencies, such as the Arab Standards Organization, should be made responsible for administering the code so as to avoid continued dependence on foreign institutes. There is also a need for a strong inspection agency and a specialized institute for training and research in welding.

<u>Experience of developing countries in establishment and operation of similar industries</u>

Some countries, such as India, the Republic of Korea, Brazil, Mexico, Argentina, Spain and China, have recently established pressure vessel manufacturing industries. The main problems faced by these countries were:

(a) Natural tendencies on the part of industrial development authorities to adopt the short-cut approach of turn-key projects in the chemical industry;

(b) Incentives for the import of capital equipment;

(c) Lack of basic knowledge with regard to engineering and management of chemical projects;

(d) Delay in the recognition of the importance of design skill development;

(e) Fluctuations in market demand due to the very nature of the industry;

(f) Natural tendencies on the part of technology sellers to hold onto the technology, and not to train the technology buyer's personnel fast enough;

(g) Reluctance of holders of rights to proprietary processes to encourage procurement of equipment locally;

(h) Financial and manpower problems.

These problems were solved by the industrializing countries by:

(a) Establishing local companies for engineering of chemical plants

(b) Equity participation by the collaborators;

(c) Doing away with the turn-key approach and thus controlling the equipment procurement process;

(d) Pooling of regional markets;

(e) Protective measures, and removing import incentives on capital equipment and encouraging procurement of equipment from local sources;

(f) Establishing local pressure vessel codes and appointing authorities to administer them.

Basic considerations in selection of plant size and product mix

Data with regard to existing industrial units in the region engaged in fabricated static equipment are not available but it is believed that some small facilities exist in Iraq and Egypt.

Having regard to the practices prevailing in fabrication units in industrialized countries, many of which were developed through diversification and expansion over a very long period of time, and taking note of the approach of the developing countries and also of the market conditions in ECWA countries, the following alternatives for the development of the industries in the ECWA region were suggested:

(a) Establishment of integrated industrial units for the manufacture of process vessels and heat exchangers, furnaces and partly storage tanks;

(b) Establishment of separate units for exchangers keeping the rest of the categories of products in an integrated way;

(c) Establishment of units on split coverage based on weight ranges.

Alternatives (b) and (c) would be possible if the demand for fabricated equipment were large enough to allow production to be split up into sections.

Taking into account demand and its distribution and the fact that manufacturers of fabricated equipment take time to build up their market creditability, necessitating intensive rather than extensive efforts to overcome these problems, two production units with annual capacities of 30,000 tons and 20,000 tons were examined for their economic viability. From the point of view of location, the above alternative plant capacities were examined with reference to conditions in the Gulf (high cost) and non-Gulf (low cost) countries.

Economic analysis of alternatives

The economic analysis of the two alternatives gave the following results:

Summary Results of Analysis of Various Alternatives

Description	Location and annual capacity			
	Gulf countries		Non-Gulf countries	
	20 000 tons	30 000 tons	20 000 tons	30 000 tons
1. Total fixed capital (all equity basis (millions of US dollars)	84.5	124.2	74.2	109.3
2. Total fixed capital (with long-term loans) millions of US dollars)	90.0	133.0	79.0	117.0
Out of which: equity	45.0	66.5	39.5	58.5
loan	45.0	66.5	39.5	58.5
3. Working capital (assumed at short borrowing) (millions of US Dollars)	21.3	30.9	19.3	28.3
4. Annual value of sales at full production capacity (millions of US dollars)	88.9	133.4	88.9	133.4
5. Number of persons employed	1,855.0	2,490.0	1,855.0	2,490.0
6. Period (years)	8.5	6.7	4.7	4.3
7. Average non-discounted rate of return over 10 years on total fixed capital (percentage per annum)	6.0	10.5	19.8	23.2
8. Internal rate of return (percentage per annum)	5.2	8.2	13.3	14.8

The above results were based on:

(a) A plant construction period of three years and a production build-up period of four years;

(b) There being no import duties on any of raw materials, or plant and equipment or construction materials.

Except for the plant with the 20,000 tons annual production capacity in the Gulf countries, all the alternatives could be reasonably profitable. However, it should be borne in mind that the cost of transporting the final products was not included; if it were then it would make the Gulf countries a more favourable location. This analysis should be carried out at the time of undertaking detailed studies.

Alternative approaches for development

In order to formulate the alternative approaches, a number of factors have to be taken into consideration:

(a) The manufacture of storage vessels is simple and many such vessels for the storage of incoming raw materials and outgoing products in the chemical industry could be manufactured on site. The regional fabrication industry should limit itself to making "in process" storage vessels;

(b) A small portion of the demand for pressure vessels such as heavy or special reactors should be met through imports;

(c) In the event of low demand due to market fluctuations, limited diversification could take place in the manufacture of similar technology equipment such as cement kilns, ball mills, beat digesters, etc.;

(d) In view of long gestation periods, it is unlikely that any such facility would be ready before 1985, or reach full production before 1989.

There are two possible alternatives in this situation:

(a) To establish one fabrication unit in the Gulf region with a capacity of 30,000 tons and a smaller plant in one of the ECWA countries on the Mediterranean coast;

(b) To establish one fabrication unit with a capacity of about 50,000 tons in the Gulf region.

Both these alternative would give the following annual capacities:

-	Pressure vessels	17,000 tons
-	Heat exchangers	12,500 tons
-	Furnaces	10,000 tons
-	Storage vessels	10,000 tons

In both cases, the expansion of the units should be achieved through diversification to include higher technology products such as nuclear steam generators.

The fabrication industry should be considered a highly strategic one. Although the concetration may give better financial results, it may also lead to greater vulnerability.

1.9 Summary of discussions

The Group expressed great satisfaction with the quality of the study and the way positive and negative aspects and the problems and prospects were brought out and discussed in the study.

One expert expressed the opinion that the manufacture of pressure vessels and heat exchangers is very difficult and wondered whether the time was ripe to consider its establishment in the region. He recommended that the build-up of basic infrastructure especially the engineering and design capabilities should precede the establishment of such industry. This view was also shared by another expert. The two experts suggested that the development of the chemical equipment manufacture should be examined along with the training, standardization and build-up of engineering capabilities.

The same expert suggested that consideration be given to the creation of capacities in the region for contracting and suggested that the Group should recommend to the governments to promote and establish contracting companies at national levels.

The same expert suggested that in view of the high transportaton cost of the end products, the location of the fabrication facilities should be centred in the Gulf region as most of the development of end-use industries is taking place there.

Other experts disagreed with some of the views expressed above, stating that that area of capital goods deserved the highest priority as there was a tremendous market for fabricated chemical equipment, which constituted the bulk of investment in the chemical industry projects. In addition to pressure vessels, they thought that consideration should be given to the piping, fabrication and manufacture of valves and fittings. They suggested that that activity should be undertaken under the umbrella of APICORP and OAPEC, the latter having already established an engineering and design company specializing in servicing petro-industries.

One expert suggested that the question should be reviewed in light of the fact that there were already small-capacity fabrication units in some countries.

Another expert expressed the view that the group should recommend the establishment of a company to promote that industry; in addition, the organization to be responsible for promotion of such a company should be identified in order to expedite implementation.

Some experts considered that such plants should also manufacture equipment for industries other than the petro-industries, because their productions would be flexible enough to manufacture a variety of equipment. However, in view of the large market in the petro-industries efforts should concentrate, at least initially, on meeting the needs of this group. It was thought that general-purpose plants having completely versatile production facilities and catering for a wide spectrum of end-uses would not be successful because of inherent difficulties in design specialization, production, planning and marketing.

One expert questioned whether aspects relating to build-up of capabilities to fabricate the equipment in terms of the requirements of skills, complexity and weight had been sufficiently considered in the study. It was explained that the build-up of skills was time-consuming and the manufacture of complex equipment could only be undertaken for fabrication when the requisite skills had been acquired.

Another expert thought that transportation costs should not be a factor in determining location of the fabrication facilities and cited some examples in that regard.

The same expert suggested that production build-up should move gradually from simple vessels to complex items like furnaces.

Another expert suggested that discussion of the question of exact locations was premature.

The importance of engineering and design capabilities in the successful establishment of fabrication industries was highlighted and the Group expressed the desire to have the experience of OAPEC and other organications.

An expert intervened stating that as this was such a complex area of industry, with lengthy gestation periods, its establishment required a systematic phase-by-phase approach. Other experts agreed and suggested that the Group should:

(a) Discuss what further course of action should be taken;

(b) Identify the organization which should undertake this further work.

In the debate that followed, the contradictory views of the experts led the Chair to request the OAPEC expert to brief the Group on the background and phased-out progress and so far in the establishment of the Arab Engineering Company.

A detailed presentation on the approach and modalities followed in the establishment of the Arab Engineering Company was made by the expert from OAPEC. He covered the main elements which led to the establishment of the company, and in particular, the following points:

(a) The criteria and logic of the establishment of facilities;

(b) Modalities through which the co-operation of the Arab States was effected;

(c) The problems faced in conducting the feasibility study;

(d) The conclusions of the feasibility study;

(e) The functions of the enterprise;

(f) The sectors covered by the enterprise;

(g) The programme of organizational build-up, training, marketing, etc.

The Group was very impressed by the presentation and was encouraged by the fact that positive steps had already been taken to establish engineering capabilities of this nature in the region. The experts who had earlier expressed their reservations concerning the development of such an industry at this stage concurred.

The experts generally agreed that since such projects take so long to implement and bearing in mind the importance of the industry, immediate steps should be taken by the Arab Petroleum Investment Company and OAPEC to promote the development of this industry. Mechanisms should be devised to:

(a) Define the project and elaborate on the scope of manufacturing facilities;

(b) Bring the information base to such a level that the study should take such form to include the required data and recommendations needed to help potential investors in their decision-making.

The ECWA/UNIDO Industry Division was urged to provide whatever assistance it could in this respect. The joint action might include examination of existing fabrication facilities if there were any in the ECWA region, and ways and means of establishing other prerequisites needed for the development of fabrication facilities.

D. Manufacturing electric power equipment

1.10 Basic economic and technological considerations - summary of ECWA study[1/]

Most of the national electric power networks in the ECWA region are not fully integrated. This is manifested by the use of "captive" plants to serve specific regions, communities, or industrial enterprises. Consequently, relatively small generating units of different sizes and types (including diesel units) are used. This is also true of transmission and distribution line voltages and transformer ratings. The main disadvantages are:

(a) Higher costs are incurred because the captive plants have to have their own reserve capacities in order to meet peak load requirements. This would not be necessary if the network were fully integrated;

(b) Interruption of service is more likely to occur because some loads are isolated and cannot be fed except from their particular generating plants;

(c) The inability to standardize power system hinders the integration of the region's networks or bilateral connections between adjacent networks. Such interconnections have economic and practical advantages and have been strongly advocated by concerned parties.

Although most countries of the region have adopted the 220V, 50Hz European standard, Saudi Arabia has adopted the American standard (117V, 60Hz) while Lebanon uses both the 117V and 220V low distribution voltages. This situation impedes standardization of power equiment.

The envisaged future developments in the region's power systems are:

(a) Thermal generation (steam and, to a lesser extent, gas) will become predominant. This trend is indicated by the planned power programmes, despite their short span. It is also indicated by a survey of the potential sources of energy in the region which reveals that hydro-potential, mostly in Egypt and Iraq, is limited whereas thermal resources (oil, natural gas, flared gas, etc.) are abundant. Nuclear generation is not likely to become significant before the year 2000 because of technical complexities (operation and safety control) and economic constraints, including the high cost of uranium as well as the cost of equipment which is not competitive with thermal equipment as

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1/ Joint ECWA/UNIDO Industry Division, The Viability of Establishing Regional Electric Power Equipment Industry in the ECWA Region, Basic Economic and Technological Considerations, volume II, Part 1.

regards unit sizes below 600 MW. Most of the region's networks will not be able to accommodate 600 MW units in the foreseeable future.

(b) The size of power-generating units will become larger; whereas a 100 MW steam unit is considered to be large now, many units will be in the 300 MW range during the next decade. Simultaneously, higher transmission line voltages will be used, (e.g. 500 kV or higher). Economies of scale in power generation and transmission, or sometimes the geographical remoteness of major power sources, force electricity authorities to seek larger generating unit sizes and higher transmission voltages. This trend is indicated by the planned power programmes.

The growth of the region's power systems is projected as follows:

		Average Annual Increase			
		1981-85	1986-90	1991-95	1996-2000
(a)	Installed generation capacity (MW)	2 628	4 763	5 029	7 679
(b)	Transformers capacity (MVA)	14 196	26 206	27 312	41 431

Even with the projected significant increase in generation capacity, the region's per capita consumption in the year 2000 (2,493 kwh) will be about 40 per cent of the per capita consumption in the developed regions of the world in 1975 (5,731 kwh).

The corresponding growth of electric power equipment is estimated below:

		Average Annual Increase			
		1981-85	1986-90	1991-95	1996-2000
(a)	Capacity of turbines and generators (MW)	2 628	4 763	5 029	7 679
(b)	Capacity of small (0.25-1.25 MVA) distribution transformers (MVA)	3 165	5 730	6 041	9 200
(c)	Capacity of medium power (6-40 MVA) transormers (MVA)	4 762	8 520	9 041	13 853
(d)	Capacity of large power (75-200 MVA) transformers (MVA)	6 269	11 956	12 230	18 378

Projections for cables and wires are given under cables manufacturing section B.1.6, and projections for other equipment, such as switchgear, will be given at a later date.

The corresponding average annual investment in turbines and generators (including control and thermal equipment) and transformers is estimated below. Investment figures pertain to the ex-factory cost of equipment.

		Average Annual Investment (Millions of US dollars at Constant 1979 Prices)			
		1981-85	1986-90	1991-95	1996-2000
(a)	Turbines, generators and associated equipment	247	442	473	722
(b)	Small distribution transformers	36	65	68	104
(c)	Medium power transformers	46	82	87	133
(d)	Large power transformers	44	84	86	129
	Total	373	673	714	1 088

An examination of the supply aspect of electric power equipment indicates that the heavy power equipment (turbines, generators, power transformers) industry is characterized as follows:

(a) The equipment is large in terms of unit capacity and physical size. One large unit may take as much as 20 per cent of the factory's production capacity and require up to two years to produce;

(b) The equipment is invariably custom-designed according to the customer's specifications. Each customer has his own specifications which take into account safety regulations applicable to his country;

(c) The product group or unit size form the basis for specialization by small manufacturers and by divisions (or plants) of larger firms;

(d) Large orders and longlead-times demand large amounts of working capital. Powerful production equipment and facilities require large capital investment. The trend towards larger equipment and the introduction of nuclear energy for the generation of electrical power have necessitated the expenditure of huge amounts of money on R & D - as much as 8 to 10 per cent of sales;

(e) The large size of individual orders and the irregularity of orders cause peakings in the factory's workload, make programming of the overall production activity very critical and prompt major manucturers to produce a wide range of products;

(f) The manufacture of heavy power equipment requires a wide range of materials as well as semi-finished and finished products from the chemical equipment, electronic equipment, metal products, and other industries. The major materials are copper and silicon steel. In the industrialized countries, manufacturers of power equipment normally procure principal components (forgings and castings, etc.) from specialized manufacturers. The absence of local supporting industries is one of the main problems facing power equipment industries in ECWA countries. In the initial phases of production, those industries can import those components from international manufacturers yet ultimately they must develop local capabilities.

(g) Because of the huge capital investment and high cost of R & D and the relatively limited number of customers (electricity authorities, large industrial enterprises, etc.), competition has become very keen and many mergers have taken place. Thus, the industry at present is dominated by a few large multinationals which possess most of the technology and dominate the open market for the supply of power equipment. Those large companies produce equipment in developing as well as in industrialized countries in order to secure their markets.

The main problems facing the establishment of power equipment industries in developing countries are:

(a) Ability of the domestic market to absorb the output of the local industry;

(b) Development of local technical and managerial skills;

(c) Acquisition of technology, including new product designs and production processes, and the required skills;

(d) Development of the organization which could implement projects of this scope;

(e) Development of supporting industries which would, at least initially, exert a negative influence on the cost of production. Before starting the manufacture of heavy power equipment, comprehensive plans to resolve those issues must be formulated. In the case of supporting industries, their role in serving other industries (e.g. heavy mining equipment) should be taken into account.

The above issues are of particular importance to the ECWA region in view of the fact that existing power equipment industries are very limited (mainly small distribution transformers) and are undertaken on a national basis (in Egypt and Iraq).

The manufacture of power equipment in the region is analyzed in this study in the context of a regional industry. Its home market will be the collective markets of the region, and may involve establishing factories in various countries of ECWA. The form which it will take and the location of the factories must be determined in detailed feasibility studies.

The relative advantages of a regional industry vis-a-vis a national industry are:

(a) Larger market which reduces the unit cost of production and icreases the local added value;

(b) More efficient utilization of resources (capital and skilled labour) in the region as a whole;

(c) Development of regional co-operation with resulting social and economic advantages to the people of the region.

On the other hand, a regional industry faces unique problems stemming from its links with numerous government and electricity authorities. A prerequisite to its success is the continuous co-operation among the governments of the region.

The regional industry must establish links with the following:

(a) Electricity authorities in order to standardize equipment specification and sizes, and to formulate long-range production plans. Long-term product planning is particularly important with regard to heavy power equipment in order to avoid slack production periods and excess capacity at the factory.

(b) Governments of the region in order to resolve issues relating to trade policies, training of staff in local institutions, acquisition of capital, etc.

(c) Sources of technology, mainly international manufacturers of power equipment. The scope of assistance sought could be very wide and range from planning the factory to training local staff, to after-sales service, etc.

The selection of products for the regional industry is based on the following criteria:

(a) Size of the market: the ability of the regional market to absorb the output of a viable manufacturing plant and, concurrently, the inability of national markets to individually absorb the output of such a plant;

(b) Status of technology: products whose technology is expected to become obsolete are discarded;

(c) Selected products are given priority according to their relative value in the power system, their impact on other equipment in the system, their role in the transfer of technology to the region, and the resources required for producing them.

Application of the above criteria to turbines, generators, and transformers reveals the following:

(a) Turbines and generators

(i) With reference to the projected demand for this equipment, the regional market, even now, could absorb the output of a 2,000 to 3,000 MW manufacturing plant which is generally considered by international manufacturers to be the minimum viable plant size. On the other hand, none of the national markets, even Saudi Arabia or Iraq, could absorb the output of such a plant at any time during the projection period 1980-2000;

(ii) The basic technology of turbines and generators has been fairly stable. Future research efforts are expected to concentrate on the development of new metal alloys and insulation materials and better cooling systems, as well as more precise methods for producing, assembling, and testing the ever-increasing physical sizes and power capacities of those products;

(iii) Turbines and generators are the highest cost items in the power system. Their combined cost amounts to about 40 per cent of the cost of thermal power plants;

(iv) Turbines and generators are the heart of the power system. They have a decisive influence on other equipment in the system, e.g. ratings of power transformers, transmission line voltages, etc.;

(v) Compared with other power equipment, even large power transformers the level of technology required for manufacturing turbines and generators is very high. Consequently, their manufacture stimulates the transfer of technology to the region.

(b) Transformers

(i) With reference to the projected demand for transformers, the regional market for small distribution (0.25-1.25 MVA) and medium power (6-40 MVA) transformers, even now, could absorb the output of a 3,000 MVA manufacturing plant which is generally considered by international manufacturers to be the minimum viable plant size. On the other hand, none of the country markets could individually absorb the output of such a plant at any time during the projection period (1980-2000). As for large power (75-200 MVA) transformers, the projected markets of Egypt, Iraq and Saudi Arabia could individually absorb the output of a minimum viable manufacturing plant (about 6,000 MVA according to international manufacturers) during the next decade. Bearing in mind that large power transformers, as against other categories, require the highest level of manufacturing technology and skills, and that small and medium power transformers are geared to regional manufacture, it seems logical to produce this category of transformers on a regional basis as well;

(ii) Transformer technology has been well stabilized. Future research is expected to concentrate on the development of better insulation and non-magnetic materials, etc. Moreover, at least for small (distribution) transformers, the region possesses the basic manufacturing skills and infrastructure. This technological base could be developed to a level compatible with the requirements of larger transformers sizes;

(iii) The relative cost of transformers in the power system is probably second only to turbines and generators if boilers, wires and cables, which are invariably procured from specialized manufacturers, are not included.

Based on the above analysis, it seems that turbines, generators, and transformers are potential candidates for regional manufacturing. This preliminary result was further examined in detailed pre-feasibility studies.

1.11 Pre-feasibility of manufacturing turbines and generators - summary of ECWA study[1/]

The pre-feasibility study was confined to steam and gas-generating plants because the region is well-endowed with the needed natural resources. The selected generating unit sizes are:

Steam - 100, 150, 300 MW
Gas - 50, 100 MW

The standardization of generating units in the above sizes has the following operational and manufacturing merits:

(a) It covers the projected increase in the size of future generating plants;

(b) It stimulates efforts to standardize the region's networks and equipment;

(c) It renders the manufacturing operation more economical: less designs, less inventory, more efficient factory loading, etc.

Although the manufacturing data (including cost) used in this study pertain to specific typical products (150 and 300 MW steam turbines and

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1/ Joint ECWA/UNIDO Industry Division, The Viability of Establishing a Regional Electric Power Equipment Industry in the ECWA Region, Pre-feasibility Study on Turbines and Generators, volume II, part 2 generators), they can be regarded for the purposes of this study as representatives of the whole product range.

The manufacture of steam turbines, gas turbines and generators should be undertaken in the same factory. The manufacturing linkages between steam and gas turbines are quite strong and the differential investment for producing gas turbines in a steam turbines factory is low. As for generators, their manufacture entails the use of complex expensive machinery, and specialized skills are required for manufacturing turbines, especially those associated with rotors. The other advantages of the joint-manufacture arrangement are the utilization of transporting and handling facilities in the factory.

However, the manufacturing links between turbines and generators, which are rotating machines, and transformers, which are static machines, are insignificant and suggest the use of separate factories. The same is true of other power equipment (e.g. switchgear).

The full capacity of the factory is assumed to be 3,000 MW which would be attained in 13 years. The maturation period would consist of a 4 year pre-production (construction) phase and a 9-year production phase. The actual length of those phases would depend on the product mix, local conditions (technological infrastructure, etc.) in the country hosting the factory. Thus it would be more precisely projected in a feasibility study where whose factors could be better defined.

The production of a turbine or a generator entails many operations; a great number of components are manufactured and assembled and extensive testing is carried out at various phases of the production process. More and more operations are becoming automated, utilizing computer-controlled machines and electronic test equipment.

In the manufacture of turbines, the rotor is the most complex part; machining its huge shaft is an important and demanding operation. The manufacture and assembly of the rotor blades, within very stringent tolerances, is another important operation. For generators machining the rotor, manufacturing properly insulated coil winding and assembling them in the stator are the main operations.

The manufacture of turbines and generators necessitates the use of high-quality materials (copper, silicon steel, etc.). During the first years of production, the factory must import a higher share (value-wise) of finished components than it produces locally. The degree of localization may increase, ultimately, to 82 per cent for turbines, 96 per cent for generators, and 100 per cent for associated thermal equipment (condensors, HP and IP heaters, etc.). These percentages which represent the experiences of international manufacturers in other parts of the world depend on many factors including the determination of the regional industry to achieve a high degree of self-sufficiency.

Components such as rotors will continue to be purchased, a practice followed by many international manufacturers of heavy power equipment.

The investments needed for manufacturing such components (in foundries and forging plants) is so great that it is left to specialized suppliers (steel mills, etc.). The procurement of components may be undertaken with the assistance of the collaborating manufacturer (licenser, etc.). In such a case, it should be stipulated in contractual documents.

The required production machinery and equipment is quite expensive and complex. It should be mentioned in this context that the machinery required for producing 300 MW units is also capable of producing larger unit sizes; the threshold is about 500 MW. Moreover, the same machinery can produce industrial turbines and generators as well as a variety of motors.

The regional industry should accept only machinery which conforms to international standards in order to avoid the difficulties of getting suitable spare parts and replacements.

By and large, a highly skilled work-force is required. However, the skills needed are not available in the region. The development of a capable work-force is one of the most important conditions for the success of the regional industry. Training should be initiated with the help of the collaborating manufacturer right at the start of the pre-production phase. It should continue indefinitely, though gradually becoming less intensive. At first, the high cost of training will reduce the profitability of the industry. In the long-term, however, it will prove to be a very worthwhile investment.

The manufacture of turbines and generators can only be pursued with the assistance of a reputable internaional manufacturer of similar products. The scope of the required technology, and the form of collaboration (licensing, joint venture, etc.) should be precisely defined in the feasibility study. In general, the scope of the technology could include:

(a) Technical know-how for the product mix, including specification of the product, technical software, etc;

(b) Continuous flow of new R & D results;

(c) Know-how relating to production, installation, and after-sales servicing of the products;

(d) Designing production facilities, and specifications of machine tools, equipment, materials, and components;

(e) Documentation of the production processes and production control systems;

(f) Operational procedures and systems relating to inventory, incoming inspection, testing, and quality control;

(g) Training;

(h) Development, ultimately, of a local R & D capability.

The financial aspects of the manufacturing operation were analyzed with respect to two groups of countries, categorized according to their average wage levels and construction costs. Group I included the oil-exporting countries, and group II the non-oil exporting countries. The results are shown in the following table.

Summary decision matrix for turbines and generators 3 000 MW/year output

No.	Item description	Group I	Group II
1.	Total fixed capital, all equity basis (millions of US dollars)	331	307
2.	Working capital, assumed short borrowing (millions of US dollars)	67	66
3.	Number of persons employed	1 211	1 211
4.	Pay-back period (years)	10	9
5.	Average undiscounted rate of return over 15-years-period on total cash (percentage per annum)	9	12
6.	Internal rate of return	6	8
7.	Unit cost of production (US dollars per MW)	78	76

Source: Joint ECWA/UNIDO Industry Division.

Conclusions

(a) The manufacture of turbines and generators, although economically viable, would demand huge investment, entail a long pay-back period, and offer a moderate internal rate of return;

(b) Based on the results obtained in this study, which should be substantiated in a detailed feasibility study, the plant capacity of 3,000 MW assumed in this study would need to be increased. It must be noted that the regional market would be able to absorb the output of 5,000 MW factory by the time the factory matured (around the middle of the 1990s);

(c) The location of the factory would not significantly influence the cost of production because of the high proportion of the cost of materials to the total cost of production;

(d) During the first years of production, the factory should not produce unit sizes larger than 100 MW. The experience so gained should be put to use in manufacturing larger and more complex sizes, e.g. the 150 MW and 300 MW units, at a later stage. This build-up of manufacturing capabilities would be in harmony with the projected increase in the sizes of the generating units which will be introduced into the region's power systems.

(e) Although the factory would be designed to manufacture electric power turbines and generators, other types of turbines and generators (industrial, marine, etc.) as well as motors could be manufactured there. Such an arrangement might smooth the work-load peaking usually experienced in heavy power equipment factories;

(f) The execution of this project would need extensive preparations, including:

(i) Standardization of unit sizes;

(ii) Development of the necessary technological infrastructure, including supporting industries;

(iii) Development of an organization capable of implementing projects of this scope;

(iv) Collaboration with international manufacturers;

(v) Selection of the manufacturing site; the factory should be accessible to highways or railroads and located near sources of electrical power and water.

1.12 Pre-feasibility of manufacturing transformers - summary of ECWA study[1/]

The classification of transformers into three groups - namely small distribution (0.25-1.25 MVA), medium power (6-40 MVA) and large power (75-2000 MVA) - reflects their manufacturing requirements including the level of technology, the quality of materials, the skills of workers, production processes, etc. All these are influenced by transformer size. Within each category, a minimum number of standard sizes should be adopted by the regional industry to increase its profitability (fewer designs, smaller inventory, etc.) and to facilitate the standardization of equipment in the region's networks.

From an operational point of view, the range of these categories would cover the expected requirement of future power networks: from very small distribution transformers to large power transformers compatible with future large generating plants and high transmission voltages e.g. 500 KV.

Although the manufacturing data (including cost) used in the study pertain to specific typical transformers, these transformers can by regarded for the purposes of the study as representative of the entire range of transformers.

The manufacture of transformers would be undertaken in separate factories, each specializing in a particular category. This arrangement would stimulate balanced industrialization in areas in different states of development.

The establishment of separate transformer factories would not exclude the possibility of establishing centralized facilities in one factory to supply certain components (e.g. finished laminations, condenser bushings, etc.) to all factories. In fact, such arrangements are normally adopted because they are more economical.

The full capacities of the factories are assumed to be 6,000 MVA each for small and medium power transformers, and 10,000 MVA for large power transformers. These capacities would be substantially larger than the minimum viable plant capacity suggested by international manufacturers of power equipment, yet less than the capacity required by the regional market at the beginning of the next decade.

Full capacity would be attained in 8 years for small and medium power transformers, and 10 years for large power transformers. The pre-production (construction) phase in all cases is assumed to be 3 years. As in the case of turbines and generators, the maturation period would be more precisely projected in a feasibility study.

1/ ECWA, Economic Commission for Western Asia, The Viability of Establishing a Regional Electric Power Equipment Industry in the ECWA Region, Pre-feasibility Study on Transformers, volume II, part 3.

The production of a transformer consists of many operations: core assembly, coil winding, core and coil assembly and connections, moisture removal, fabrication of tanks and radiators, tanking and oil filling, and testing. These stages are practically the same for all transformer sizes; however, the manufacture of higher voltage size transformers would require specialized skills in quality control, processing, and high voltage testing. Moreover, for small sizes, certain operations such as coil winding are automated and lend themselves to serial production. In all cases, the moisture removal and first oil filling of the transformer are two operations which determine the product's durability.

The materials required for manufacturing transformers include steel sheets, plates and tubes, copper strips and rods, insulating materials, non-magnetic materials, etc. The quality of material is proportionate to transformer size. Insulation, heat, and losses become more critical as the size of the transformer becomes larger.

During the first years of production, certain finished components such as winding assemblies, especially for larger transformer sizes, would be imported. The degree of localization might ultimately reach 100 per cent for the entire product range. This depends on many factors including the determination of the regional industry to achieve a high degree of self-sufficiency. Procurement of components might be undertaken with the assistance of the collaborating manufacturer (licenser, etc.). In such a case, it would be stipulated in contractual documents.

Production machinery and equipment would be needed for the following operations: welding and machining of tanks, metal works, windings and insulation, cores, bushings, assembly, and testing. The last two operations would require the largest investment in capital equipment, especially for larger transformer sizes.

The regional industry should ensure that all machinery and equipment conform to international standards in order to avoid the difficulties of getting suitable spare parts and replacements.

The level of skills required is directly proportionate to the size of the transformer. For distribution transformers, the most demanding skills are required for electrical testing. As size increases, more specialized knowledge and skills in high-voltage testing, processing, and quality control become necessary. The development of a capable work force is perhaps the most important condition for the success of the regional industry. As in the case of turbines and generators, staff training must begin right at the start of the pre-production (construction) phase and become a permanent feature at the factory. It should be noted that the region, specifically in Egypt and Iraq, possesses the basic skills for manufacturing small power transformers. Those skills could be developed to the level required for manufacturing medium and large power transformers.

The manufacture of transformers, especially medium and large, should be pursued with the collaboration of a reputable international manufacturer of similar products. The scope of the required technology, and the form of collaboration (licensing agreement, joint venture, etc.) should be precisely defined in the project feasibility study. In general, the scope of technology includes:

(a) Technical know-how for the product mix, including specification of the product, technical software etc.;

(b) Continuous flow of new R and D results;

(c) Know-how relating to production, installation, and after-sale servicing of the products;

(d) Designing production facilities, and specifications of machine tools, equipment, materials, and components;

(e) Documentation of the production processes and production control systems;

(f) Operational procedures and systems relating to inventory, incoming inspection, testing, and quality control;

(g) Training;

(h) Establishment, ultimately, of a local R&D capability.

The financial aspects of the manufacturing operation were analyzed with respect to two groups of countries categorized according to their average wage levels and construction costs. Group I included the oil-exporting countries, and group II the non-oil exporting countries. The results are shown in the following three tables:

Summary decision matrix for small distribution (0.25-1,25 MVA) transformers, 6 000 MVA/year output

No.	Item description	Group I	Group II
1.	Total fixed capital, all equity basis (millions of US dollars)	44.0	40.0
2.	Working capital, assumed short borrowing (millions of US dollars)	14.1	13.5
3.	Number of persons employed	748	748
4.	Pay-back period (years)	4.8	4.1
5.	Average undiscounted rate of return over 10 year-period on total cash (percentage per annum) 26.9	39.1	
6.	Internal rate of return	14.8	18.6
7.	Unit cost of production (US dollars per MVA) 8.3	7.8	

Source: Joint ECWA/UNIDO Industry Divison.

Summary Decision Matrix for Medium Power (6-40 MVA) Transformers
6 000 MVA/Year Output

No.	Item description	Group I	Group II
1.	Total fixed capital, all equity basis (millions of US dollars)	51.0	46.0
2.	Working capital, assumed short borrowing (millions of US dollars)	11.3	10.6
3.	Number of persons employed	827	827
4.	Pay-back period (years)	6.0	5.2
5.	Average undiscounted rate of return over 10 year-period on total cash (percentage per annum)	16.6	27.5
6.	Internal rate of return	10.3	15.0
7.	Unit cost of production (US dollars per MVA)	7.3	6.7

Source: Joint ECWA/UNIDO Industry Division.

Summary Decision Matrix for Large Power (75-200 MVA) Transformers
10 000 MVA/Year Output

No.	Item description	Group I	Group II
1.	Total fixed capital, all equity basis (millions of US dollars)	69.0	61.0
2.	Working capital, assumed short borrowing (millions of US dollars)	13.0	12.0
3.	Number of persons employed	1 027	1 027
4.	Pay-back period (years)	7.4	6.0
5.	Average undiscounted rate of return over 10 year-period on total cash (percentage per annum)	11.5	21.6
6.	Internal rate of return	7.6	12.4
7.	Unit cost of production (US dollars per MVA)	5.1	4.6

Source: Joint ECWA/UNIDO Industry Division.

Conclusions

(a) The manufacture of transformers is economically viable. The rate of return would be higher than that of turbines and generators, and would be inversely proportionate to transformer size;

(b) The rate of return and pay-back period would be influenced by plant location (group I vs. group II). The impact of the location factor would depend on the size of the transformer. Thus, it would be more profitable to locate medium and large power transformer factories in group II countries. This would also apply to the small (distribution) transformer factory. Nevertheless, such a factory could be located in a group I country with relatively little effect on its profitability compared to the other factories;

(c) Towards the end of the 1990s, the regional market would be able to absorb 50 per cent more capacity than the proposed factories could provide. This could be met by enlarging those factories, or by establishing new ones in different locations;

(d) Although a transformer factory would be equipped specifically for the manufacture of transformers because of their insignificant manufacturing links with other power equipment, other types of transformers (for instrumentation, industrial uses, etc.) could be produced in the same factory.

(e) The execution of this project would need extensive preparation, including:

(i) Standardization of transformer sizes;

(ii) Evaluation of existing transformer factories mainly for small power transformers in Egypt and Iraq;

(iii) Development of the necessary technological infrastructure and supporting industries which would provide the necessary materials for the transformer factories;

(iv) Collaboration with international manufacturers of transformers;

(v) Selection of sites for the factories, especially for larger size units which would require access to highways or railroads and proximity to sources of electrical power and water.

1.13 Summary of discussions

It was generally agreed that the studies were well prepared with respect to their coverage approach and methodology. Further, it was agreed that the studies represented an adequate basis for identification of regional projects and for action leading to their implementation.

Many experts considered that the projection of demand and consequently investment in power generation was rather low. This was acknowledged by ECWA and attributed to inadequacies and inconsistencies in statistical data and the absence of long-term national plans and forecasts. Further, it was pointed out that ECWA's projections were intended to be conservative in order to stress the economic viability of the projects even under less favourable circumstances.

The experience of India in developing heavy electrical power equipment was presented in detail by one expert. He covered the ways and means which were adopted in the training of manpower and the absorption of technology. Research and development activities connected with the development of the industry were also described. The action taken to co-ordinate between the consumer who was, in this case the electricity authorities, and the industry was also touched upon. It was mentioned that a plant with a capacity of approximately 3,000 MW might be easily increased to 5,000 MW by adding only some equipment particularly for testing.

The activities of the international cartel in this field were briefly described. It was pointed out that almost all European and Japanese companies were members of this cartel that it had been established mainly for the region's market and that it would be very important to remember this fact when making technology transfer agreements with the collaborators. It was pointed out that it would be useful to study different approaches and methods of collaboration. The importance of establishing the industry in the region was stressed. The experience of Brazil with multinationals was also presented.

Some reservations were voiced by a number of experts regarding the development of heavy equipment because of the sophisticated technology involved. It was suggested that for the present, it might be sufficient to concentrate on less complex equipment.

It was explained that the purpose of the study was to propose candidate projects on a regional basis. It was thought that less complex equipment might be developed on a national basis as is the case at present. Further, taking into consideration the gestation time, the discussion was related to the year 1995 and afterwards. It was acknowledged that the implementation of heavy equipment projects would require extensive preparations; however, that did not mean the problem would be insurmountable.

Standardization of the size of units to be produced was touched upon and the importance of co-ordination was stressed. In this respect, the present stand of electricity authorities with regard to co-ordination was mentioned. It was recommended that the establishment of a union or federation among them would be quite useful to exchange ideas and to co-ordinate activities between manufacturers and users.

The group agreed that the manufacture of transformers was viable and that practical measures should be taken to implement that project. It also agreed that it was necessary to work towards implementing the turbine and generator project and that this project should be carefully planned and implemented by phases starting possibly with small-size industrial turbines and generators and medium-sized motors.

E. Construction, automotive and agricultural machinery: an integrated development of manufacturing capacities

1.14 A framework for a regional approach - summary of issues

Manufacturing industries for construction equipment, agricultural tractors, combines and heavy commercial vehicles are closely interlinked as they have the same supply sources for their intermediates. All the above categories of equipment use automotive diesel engines, power transmission units, alternators/dynamos, starter motors and common components like filters, seals, hoses, clutches, brakes, steerings, batteries, etc. Even though designs and specifications of the particular components required for various applications may differ, their manufacturing technologies and manufacturing facilities are similar. Component manufacturing units required to cater to the needs of one category of equipment can easily cater to the needs of the other categories and thus improve their economies of scale.

Integration in developed countries

In the developed countries, the manufacturers are engaged in more than one of the above manufacturing activities. For example, International Harvester and Massy Ferguson manufacture agricultural as well as construction equipment while General Motors, Ford and Fiat manufacture agricultural machinery, construction equipment, commercial vehicles and in addition passenger cars. With such a high degree of integration, these companies find it more profitable to buy some components, sub-systems and even complete systems from outside sources. In other words, there is not one manufacturer in the world which manufctures all the components of any machine. Most of the manufacturers buy components and sub-systems like fuel systems (exception - Caterpillar), hydraulic elements, antifriction bearings, oil seals, pistons, etc. from specialist manufacturers.

Practices in developing countries

The practices in developing countries are the same: for example Escorts Tractors India sub-contracts the supply of many components. Some of these sub-contractors have been promoted and developed by the company in order to ensure regular supply of good-quality components at reasonable prices.

Need for integration

The manufacture of common components requires special equipment and technologies and is prone to economies of scale. Demand for tractors and combines in the Arab countries would not be sufficient to enable the establishment of manufacturing facilities for the special components for this industry alone. This is also true of construction equipment. The alternative to continue the importation of components from foreign collaborators would result in low local content and in rendering the industry more vulnerable. The other alternative would be to consider the development of manufacturing capacities to supply the components needed for commercial vehicles, construction equipment, agricultural equipment. Similar components might also be required in the manufacture of stationary diesel engines of small-and medium-sizes, small marine engines, mobile generating sets, passenger cars, etc.

Some basic requisites

Integrated development of these industries would reqire concerted efforts in co-ordination at the regional level with regard to standardization, technology acquisition and adaptation, location of industrial units and distribution of capacities, marketing and after sales service, vendor development, investment promotion etc. Broad indications of the basic needs of these determinants are given here.

Standardization

The main objective of standardization will be variety reduction so that mass-production techniques can be used in manufacture of equipment and components even at low market-demand levels. Rationalization of sizes and specification ensures changeability of systems and components and reduces production and inventory costs.

Equipment

Present demand for earthmoving and road-building equipment in ECWA countries is around 14,000 units and this is expected to be 21,000 units by 1990. This includes bulldozers, loaders, graders, scrapers, excavators, compactors, mobile cranes and paver-finishers. The first step in standardization will be to limit the types of equipment and the sizes to be used in the region.

Diesel Engines

Careful selection in the specification of the equipment to be used limits the variety of diesel engines required in each category. Using two or three sizes of super chargers with the same basic diesel engines gives enough variations in power to suit different applications. For example, a diesel engine used for a low-capacity bulldozer can be used as a primemover for a medium-size loader, grader, scraper, compactor, etc. This practice is followed by all the manufacturers of constructon equipment in the world.

Components

The components that best lend themselves to standardization are those used in diesel engines. Using a modular approach in design, the variety of components such as pistons, lubricant and water pumps, filters, supercharger, fuel line elements etc. can be drastically reduced. Similarly, hydraulic elements, steering gear components and electrical and hardware items for various categories of equipment can be standardized. In the initial stages the main problem will be the rationalized selection of the standard sizes available on the market.

Technology acquisition

A number of technical collaboration agreements have been signed between investors in Arab countries and the major producers of agricultural equipment, commercial vehicles and construction equipment. The next step towards raising the level of local manufacturing content would be to take stock of these agreements, to examine the specifications of the equipment they have decided to assemble or manufacture and to rationalize the specifications of diesel engines that would be suitable for incorporation in the equipment.

The second step would be to look for possible collaborators who could provide the technology for the manufacture of diesel engines to the rationalized specifications. This would have to be followed by adaptation of the finally selected diesel engines in the equipment to be manufactured through some design modifications in mounting and transmission systems.

The above procedure should also take into consideration the collaboration agreement for manufacture of diesel engines already in force in the region. Subject to the contents of existing collaboration agreements, it should not be much of a problem to rationalize the specification of diesel engines for tractors and combines because of their limited range. As there are very few such agreements relating to earth-moving and road-building equipment, it should be quite simple to rationalize the specifications of engines for these. Problems might be more complex in the case of commercial vehicles because of the number of existing collaboration agreements. At the same time as the establishment of plants for manufacture of diesel engines, modifications to the transmission system design will have to be carried out. At this point, standardization of gears, power shift systems and hydraulic elements can be carried out. In this process, a time will come when the manufacture of tractors, earth-moving equipment and commercial vehicles in Arab countries will no longer be based on foreign collaborators'designs.

Co-operation arrangements and package approach

The manufacture of some major components and sub-systems could be economical only if produced at the regional level. However, experience has shown that co-operation can be successful provided the distribution of industrial development benefits among countries is equitable. The question of equitable distribution can be resolved if there are enough projects in the bag to be distributed. Fortunately, the group of industries under consideration does not have any special locational requirements. Furthermore, the field of automotive industries is so large that many projects would be needed to manufacture the components. This characteristic of the industry offers a large package of big andsmall projects which could be distributed bearing in mind the economic conditions in the individual countries. Again some of the projects for manufacture of components do not have to be established at regional level. These would be quite economical at subregional or even national level.

The basic criteria for the distribution of manufacturing capacities in the total package are as follows:

(a) Those components which could be manufactured at the national level should be left for development at national level, for example, lamps, oil seals, and other hardware, etc.;

(b) Some components that are also fast-moving spares could be manufactured at national plants if the scale economy permits;

(c) High technology components which are also usually scale-sensitive should be undertaken at regional level, for example fuel pumps, hydraulic elements, etc.;

(d) Items of intermediates and major sub-assemblies, for example, diesel engines and transmission line equipment, should be manufactured at regional level;

(e) Assembly and superstructure fabrication could be carried out by product specialization on a regional basis or with wider production at subregional or national levels. Only detailed studies will show which of the alternatives is economically more sound.

There might be other criteria which could be applied. Perhaps one such criterion would be that in planning the development of this industry, one should ensure more than one source of supply for components and equipment to achieve healthy competition.

1.15 Summary of discussions

Various approaches to the development of the industry were presented. The expert from the automobile manufacturing complex in Iraq, which was at the initial stages of implementation, presented the approach used in the selection of consultants, licensers and contractors and steps taken towards implementation of various units included in the complex. The products of this national complex will include passenger cars, trucks, agricultural tractors and stationary diesel engines. The facilities will include machine shops, a press shop, a foundry, a forge, a diesel engine plant and assembly plants for various products, as well as the necessary infrastructure. The output of the complex was primarily geared to satisfaction of the internal demand.

Algeria's experience in bringing about vertical integration and horizontal expansion was presented by the expert from that country. The classic approach of establishing assembly plants and undertaking the manufacture of components and sub-assemblies combined with gradual "Algerianization" of the management was adopted in this case.

The experts from AIIC and ECWA presented the approach of regional integration as well as vertical integration in creating manufacturing capacities in automobiles, agricultural equipment and construction equipment. They identified the areas where a regional approach was necessary to attain economic efficiency and indicated the activities which could possibly be undertaken at subregional and national levels. The basic objective of this approach was to make the best use of the region's resources and to distribute equitably the economic benefits of development among the countries concerned.

II. COMMON ISSUES AND PROBLEMS ASSOCIATED WITH THE DEVELOPMENT OF REGIONAL INDUSTRIAL PROJECTS

1.16 Financing regional projects - summary of issues

There are two aspects to the financing of the capital goods and heavy engineering industries, which should be emphasized. The first relates to the establishment of production capacities and the supporting physical and industrial infrastructure. The second aspect relates to the development of long-term credit facilities for the purchasing of capital goods equipment.

The investment required for the 23 projects so far identified by ECWA in the fields of heavy electrical equipment, telecommunication equipment, equipment for chemicals and petrochemicals is estimated to be over $2,000 million. This figure represents the cost of establishing the production capacity; to this one must add the cost of building the physical and industrial infrastructure. In addition, there is the cost of developing technological capabilities such as project and product design, R & D and manpower-training, which are essential for the future development of the engineering industries.

The most important sources for the financing of regional projects are the joint Arab ventures already in operation, they include:

(a) The Arab Industrial Investment Company which is the Arab League holding company in charge of implementing and financing engineering, electrical and electronic joint Arab projects;

(b) Arab financial institutions. Up until 1978 total loans granted to the manufacturing sector amounted to $723 million or 11 per cent of total cumulative loans ($6,586 million) extended by the various Arab financial institutions.1/ It is to be noted that cumulative AFESD loan for the manufacturing sector (1974-1978) was $152 million or 15 per cent of the total loans of $1,030 million granted for all activities. Cumulative KFAED loans to manufacturing between 1962 and June 1978 totalled $347 million or 20.3 per cent of their total loans of $1,709.4 million. In contrast, the contribution of SFD, the biggest Arab financial institution (sharing about 45 per cent of the total funds), to financing the manufacturing sector has been insignificant;

(c) Joint ventures financed by agreements between two or more Arab governments;

(d) Joint ventures financed by the private sector or with mixed private and public ownership.

1/ These include ADFAED, ABEDA, AFESD, IDB, KFAED, OPEC Special Fund, SFD.

Owing to the magnitude of the total investment required, serious consideration should be given to the establishment of a special fund to finance the development of these industries. Part of this fund could be blocked for extending soft loans, and grants for the development of the physical and industrial infrastructure needed for these industries.

Producers of capital equipment are backed up by a system of export credit which offers easy credit terms to finance the purchase of equipment. The provision of export credit on a short-term basis could be provided by the commercial banks. However, credit facilities for the purchase of capital goods equipment in the medium-and long-term need to be developed, as these industries are developed.

In order to provide refinancing facilities and to facilitate direct participation in schemes that could be sponsored by specialized national industrial development banks as well as regional Arab financial institutions, a system of financing needs to be developed. Such schemes would provide refinancing to eligible national, commercial and specialized industrial and development banks in order to augment their financial resources. Schemes of direct financing could be developed by regional and/or national development banks and finance institutions, as could the schemes conceived with the partnership and participation of the national commercial and central banks of member countries concerned.

1.17 Machinery for implementing regional industrial projects - summary of issues

The development of an industrial project at the regional or subregional level requires from the outset an organizational structure and the machinery to make plans to carry out the consultations and negotiations necessary for its implementation, its subsequent operation and its future development within an international framework.

In this context, the institutions that have developed within the framwork of the Arab League system are of relevance and their experience might be usefully discussed here since they might provide the means for promoting and implementing regional projects. They include: (a) Arab joint ventures; (b) regional financial institutions particularly the Arab Fund for Economic and Social Development; and (c) the Arab Industrial Development Organization.

Arab joint ventures constitute a fairly recent experience in the region. It was not until the early 1970s when there was a tremendous increase in oil revenues accruing to the oil-producing countries of the region, that notable efforts by the Arab League, Arab institutions, governments and private investors succeeded in the establishment of a number of joint ventures in the fields of agriculture, mining, manufacturing energy, transport and communications, construction, insurance and tourism. Joint ventures can be broadly classified as follows:

(a) Joint ventures promoted directly under the Arab League system. These include:

(i) The Arab Company for Industrial Investment;

(ii) The Arab Company for Pharmaceutical and Medical Supplies;

(iii) The Arab Company for Mining;

(iv) The Arab Company for Development of Animal Wealth;

(v) Companies sponsored by OAPEC including:

- The Arab Maritime Petroleum Transport Co.;
- The Arab Ship Building and Repair Yards;
- The Arab Petroleum Investment Co.;
- The Arab Petroleum Service Co.;

(b) Arab joint ventures sponsored by government under bilateral and multilateral agreements;

(c) Mixed private/public sector joint ventures;

(d) Private Arab joint ventures;

(e) Joint ventures sponsored by financial institutions including regional industrial investment companies.

About 30 Arab joint industrial ventures have been formed and are, at present, at different stages of implementation; they include a number that are already in operation. The corporate arrangements and the experience of these joint ventures could provide guidelines for the future development of regional industrial projects.

However, the institutions set up under the Arab League might be the main instrument through which regional industrial Arab projects could be promoted. These institutions were set up to develop new production capacities in order to promote the development of economic interdependence and ultimately industrial integration among the Arab States.

The development of engineering industries at the regional level poses a set of problems additional to those usually faced by the existing joint ventures. A number of these industries have been basically resource-based, catering primarily for the export market. In contrast, the proposed engineering industries will be catering primarily for the local regional markets. Therefore, member countries need to come to some agreement regarding such matters as: recruitment and employment policies and procedures, purchase of inputs and raw materials, whether local or imported, and most importantly a joint free-trade regional market for the products of these projects. In addition, privileges, incentives and promotion measures need to be worked out for such projects at the early stages of development.

Some of these institutions, especially those that were established under OAPEC sponsorship as well as the Arab Mining Co., have gained some experience of corporate arrangements as holding companies, and of the problems associated with the implementation and operation of joint ventures. The pioneer enterprises are in a position to provide guidelines to the companies that are still at early stages.

The Arab Fund has gained some experience in promoting the development of certain industrial projects as joint ventures, for example, the white cement project between Jordan and Syria; the agricultural machinery project negotiated recently between Iraq and Algeria and the joint cement plant between Morocco and Algeria. It would be useful to study the process of consultations and negotiations that took place between interested member countries in an effort to prompt the implementation of regional projects. Similarly, it might be worthwhile examining the experience of OAPEC. Based on past experience the question arises as to whether the existing systems are the best means for promoting the development of regional projects, and more specifically, to what extent might the UNIDO experience relating to the system of consultation be modified and used by the Arab League to suit the Arab environment.

A supra-national authority or element thereof needs to be granted to the existing institutions, in this case to the sectoral investment holding companies sponsored by the Arab League. It is necessary to ascertain whether these institutions could ultimately evolve as "commissions" for sectoral regional co-operation and planning, with supra-national authority gradually being vested in the most relevant experience in this field, i.e., that of the European Steel Community, the predecessor of the Economic European Community.

Of particular interest is the experience of the Andean Group relating to the practice of integration at sectoral level which requires regional sectoral programming. Another relevant aspect of the Andean Group's experience relates to sectoral programming that includes equitable distribution of benefits derived from such integration. Special treatment is given, while distributing the benefits, to less developed countries, namely Bolivia and Ecuador.

The organizational structure of the Andean Group includes the Commission and the Junta. The Commission is the policy-making body, with each country having two representatives, an official voting delegate and alternates. The Junta, on the other hand, functions as the Andean Group secretariat, providing it with considerable budgetary and jurisdictional independence. The technical quality of its staff and stability of its membership reinforces its regional quality.

1.18 Standards and specifications - summary of issues

One of the basic ingredients needed for the growth of engineering industries, especially those engaged in the manufacture of capital goods, is the existence of a comprehensive system of standardization at all levels - international-national, industry or enterprise. In the engineering industry, this assumes great importance because of the vast range of the products, the nature of engineering processes and their variations to suit different production requirements and the variations in product designs to suit requirements of the consumer.

The countries of the ECWA region have to import engineering equipment because their own engineering industries cannot supply the needs generated by their rapid development. The result has been that products designed primarily to suit the conditions prevailing in the home countries of the supplier and manufactured to their own standards, are being used in ECWA countries. Large stocks of spare parts are needed for which the users have continually to rely upon the original sources, in turn leading to under-utilization of the imported products. Many of these difficulties could be reduced through a regional standardization programme.

Standardization which includes certification is the only way to ensure quality. Further, unified standards for production or procurement of engineering goods can considerably reduce inventories held at all levels. This, in turn, not only reduces the capital locked up in inventories but also minimizes purchasing and inventory carrying costs. Interchangeability of components saves money and maintenance skills. With standardization, mass-production techniques can replace jobbing and batch-production techniques, reducing production costs and manpower requirements.

The engineering industry is usually skill-intensive. To the extent that the demands for skills are reduced, the industry becomes more profitable. The skill requirements can be reduced by standardizing the division of labour, the manufacturing process and the product designs. The skill requirements and thereby the labour costs can be further reduced by buying standard components or so-called "intermediates" from specialized manufacturers.

Any endeavour to manufacture capital goods without a set of basic standards will be just as good as attempting to govern a country without basic constitution or written law. Without the basic standards at national or industry level, each manufacturer would be forced to frame his own standards - for he has to do so to be operational. He will practise his own quality and dimentional standards leaving the buyer confused between his own products and those of his competitor. Without standards a kind of technological anarchy will prevail.

Most ECWA countries have established standard institutions with functions, such as standardization, metrology and industrial research. While these efforts are commendable, showing awareness and concern, they are not adequate. At the regional level, the Arab Standards and Metrological Organization has also been established.

To simplify the introduction of standardization initially, it might be appropriate for the initial stages to adopt the internationally accepted standards of the International Organization for Standards or those standards to which the engineering goods already in use in the region predominantly conform. For example, in the case of pressure vessels and heat exchangers, consideration might be given to adopting the ASME code as a start. The adoption of any code or standard by the Arab Standards Organization or by any national standard institution should follow establishment of an adequate system for inspection and certification backed by the blessings of government authorities through mandatory measures. Inspection and certification should not be left in the hands of foreign institutes, as some of these might be influenced by the interests of their member subscribers.

Adoption of popular or internationally accepted standards would be merely the first step. One must bear in mind that foreign standards are formulated according to the requirements of the particular country. These have to be adapted to suit local conditions such as local safety requirements, the climate, the availability of manufacturing facilities, the scale of production, local raw materials, and even local life-style. The whole process of selecting the basic standards of establishment of inspection and certification systems and that of adaptation should be carried out carefully - rather meticulously for once a standard has been accepted, adopted and put into use, it is difficult to alter substantially. The improvement of standards should be carried out gradually; otherwise, it could prove to be disasterously expensive.

Standards should precede or, at least, be formulated in parallel to developments in the engineering industry. Once it is decided to establish manufacturing capacities for any engineering industry product, action should immediately be taken to formulate manufacturing standards. The decision on standard is akin to the decisions on technology and selection of plant and equipment for manufacture of the product. Those developing countries which have recognized this interrelationship in the early stages of their development and adopted this procedure from the very beginning have a much more soundly based engineering industry than those which developed the standards as an afterthought.

Taking into consideration the fact that establishment of an engineering industry is already under way in the ECWA region, immediate steps should be taken to formulate standards for the products which are already being manufactured. The cables industry is one instance where standards should be introduced immediately so that the movement of products can take place freely between the countries of the region. Next, it will be necessary to list for standardization the products which are to be manufactured in the region in the future, and then those products which are being imported in substantial quantities. Other engineering goods which deserve priority in terms of standardization are those which are required for intercountry or international infrastructural projects such as trunk telephone networks, electric transmission line equipment, etc. Allied to the problem of formulating standards for the final products there will be the question of intermediate products such as fasteners, oil seals, hoses, pipes and fittings, various types of castings, forgings, extrusions, etc.; it will be enough to select internationally accepted standards with the consent of the parties concerned in the region.

1.19 Summary of discussions

Financing

It was generally agreed that the existing financing machinery within the region would be suitable for financing the proposed engineering industries, and for providing credit for the marketing of products. As a matter of fact, there are export financing facilities but they have not been used due mainly to the lack of the institutional instruments to promote export.

Standards

On the subject of standards and standardization, emphasis was given to the importance of propagating for the adoption of unified standards for some equipment to be marketed within the region for the marketability transfer of the products, as well as for economic purposes, particularly when considering the saving in spare parts inventory. However, it was thought that this could be pursued on a sub-sector basis at a later stage once the projects had been selected. In the meantime, it was thought preparatory works might start in co-operation with national and pan-Arab standardization institutions to identify those areas where action should be taken.

Some exports stated that manufacturers should not limit themselves to one line of standards; rather they should be ready to manufacture according to different international standards while setting their own in-house standards for design and production. Further, it was pointed out that standards might be a mattter of national policy, particularly in view of the fact that procurement of materials and services could not be limited to one standard if economic alternatives exist.

Mechanism for follow-up and implementation

The most urgent issue according to most experts was the development of the implementaton machinery and the approach to be adopted in accelerating the preparatory work for its realization. In this context the following ideas were brought out by a number of experts.

There might be a need for a planning group or organization, to be set up by the financing institutions interested in promotion of the projects, probably similar to the one established in Mexico.

In view of the fact that the two Arab investment companies represented in the meeting had indicated interest in some of the identified projects, these two companies should take the matter further. However, it was pointed out that ECWA, UNIDO and relevant regional institutions such as AIDO and GOIC might be involved in the formulation of those projects considered to be of a priority nature on a regional basis.

Due to differences in structure and in levels of development it is unlikely that all countries in the region would be interested in participating in all the projects immediately. The weak base and infrastructure as well as the market constraints in each country might dictate the phasing of contributions of different countries to the proposed industries. Thus, it might be necessary to adopt short-term and long-term programmes, in which case it would be necessary to determine priorities based on the needs and potentials of the interested countries. This could be achieved by a process of consultation among all countries before they endorse the collective implementation of these projects.

With regard to follow up on the recommendations based on the discussion that took place, most of the experts supported the idea that APICORP and AIIC should select projects they might be interested to study further and elaborate on the areas and range of products which merited attention by their decision makers. It was pointed out that ECWA would be reshaping some of the projects to facilitate their proper presentation to investment decision makers. APICORP expressed interest in static chemical equipment manufacturing projects; UNIDO also expressed its willingness to extend technical services to the companies concerned to develop these projects.

In this respect, one expert pointed out that a focal point for easy communication at the preparatory stage might be needed. It was also pointed out that the involvement of other regional organizations including AFSED, AIDO, GOIC and OAPEC would be very important. At a later stage, it might be advantageous to convene an inter-governmental, inter-agency meeting for consultation on the selected projects and on the facilities needed to develop these industries. Relevant national institutions and production facilities should be consulted throughout to avoid duplication, to capitalize on all resources and to determine the degree of integration necessary for the development of this industry.

III. UNIDO GLOBAL CONSULTATION MEETING

1.20 UNIDO activities in the field of capital goods industries development

The new international economic order can not be based on a continuation of the present development trends, patterns and international division of labour. The Lima Declaration as well as the objectives of the Third General Conference of UNIDO made various recommendations aimed at substantially increasing industrial production, including capital goods production in the developing countries, thus breaking away from past trends.

The statistical definition of capital goods according to the International Standard Industrial Classification gives a comprehensive description of the products of this industry. However, such a definition does not convey the important role which capital goods industries play in a country's development. The definition of capital goods should therefore be based on the economic function which they fulfil, i.e. those products manufactured by the metal-working industry which are incorporated in Gross Fixed Capital Formation, which therefore involves machines and equipment of all kinds, fixed or mobile. This definition needs to be supplemented by other characteristics such as:

(a) The degree of elaboration of the goods; and
(b) The nature of demand-economic classification.

Such a definition is much more indicative of the significance of capital goods and their central role in the economic development of a country.

This sector is not simply concerned with manufacturing; it is closely related to technical services, i.e. product design, research development, consulting engineering work, etc., in an integrated manner. The manufacturing aspects might be more easy to develop as the technology could be brought in from outside a country, but without the technical services capability it will continue to be dependent on foreign assistance, limited in its product range and without adaptation to local conditions.

The majority of developing countries depend heavily on the import of capital goods. However, once these goods have been installed, some form of supporting capital goods industry becomes necessary at least to provide maintenance, repairs and spare parts. Thus, even before any manufacture of machines and equipment begins, the capital goods industry starts to develop as a service industry to other industries. There are many developing countries which, though largely agricultural and with no production of machinery and equipment, have experience in the operation of machinery and equipment and also in maintenance. These produce parts and components on a small scale for maintenance purposes, and undertake repairs. In many of these countries, there are workshops which carry out repair and maintenance work and which could form the nucleus for the production and expansion of selected capital goods, with wider possibilities in import substitution and export promotion. Some of the small and medium-sized developing countries have already penetrated the capital goods industry and have produced simple agricultural machinery such as implements drawn by animals, handtools for mechanical purposes and for the building industry, containers, water boilers, pumps, assembly of tractors, trucks, buses and cars, etc.

For such countries UNIDO has extended technical assistance in various forms, for example:

(a) The establishment of pilot demonstration plants, as in the Sudan, Somalia, etc.;

(b) The preparation of studies to strengthen and expand metal-working industries;

(c) The establishment of metal industrial research and development centres as in Iraq, the Philippines, Indonesia;

(d) Assistance in the establishment and development of various engineering projects of vital importance such as water-lifting devices, for example, handpumps, windpumps in Ethiopia and Kenya; reconditioning of worn parts of machinery, repair and maintenance of road transport equipment as in Mali, Niger, Bhutan;

(e) Countries which have entered into local assembly and manufacture in the automotive industry have been assisted by UNIDO in the establishment of automotive testing centres; India is an example.

UNIDO has also assisted several developing countries to plan capital goods projects, by ascertaining such factors as demand for capital goods, the feasibility of development of local manufacture, identification of national priorities, the formulation, evaluation and implementation of industrial projects, the training of local counterparts, development of engineering infrastructure and services. Such projects have already been developed in Mexico, Turkey, Pakistan, Egypt, Guatemala and Venezuela. Other countries have been under consideration for possible future technical assistance including regional projects. UNIDO has co-operation arrangements with AIDO in the preparation of capital goods projects and with ECA/UNDP in the same field for the African countries.

A seminar and global preparatory meeting for the First Consultation on the Capital Goods Industry were organized by the secretariat of UNIDO in 1979 and 1980 in order to discuss strategies, instruments and prospects for the development of capital goods projects. At the same time, the following three issues were discussed and recommended for submission to the First Consultation in Brussels, from 21 to 25 September 1981;

(a) The potentialities and possible progress of capital goods industry development in developing countries; including the small and medium sized; this paper was submitted to the meeting;

(b) Technology in the service of development: this paper is not yet ready;

(c) The framework of international co-operation, including the long-term contractual arrangements for the setting up of a capital goods industry: this paper is nearing completion.

The UNIDO secretariat has just completed the First Global World-Wide Study of Capital Goods which needs some improvements before it is submitted to the First Consultation. Its main findings are summarized here below:

The contribution of developing countries to world production of capital goods was estimated at about 6 per cent, while their contribution to world consumpton was 9 per cent. It was anticipated that by the year 2000 the amount of consumption covered by local production would increase and approximately 15 per cent of world production of capital goods would be produced in developing countries. However, those estimates and their implications required further consideration.

The great majority of developing countries did not have a capital goods industry, and only about 30 countries had such an industry either partly established or in an embryonic stage. A preliminary classification of developing countries had been established with the aim of developing suitable strategies, taking into account their basic economic characteristics and their potential for development of the capital goods industry.

This deep-seated inequality manifests itself also within international trade. Developing countries supply only 2.5 per cent of the world's exports whereas their share in imports has reached 30 per cent. The market economy of developed countries provides more than 87 per cent of the exports and six of these countries (Canada, the Federal Republic of Germany, France, Japan, the United Kingdom and the United States of America) account for three fourths of this amount. The centrally planned economies provide 10 per cent of world exports.

Imbalances within the developing countries manifest themselves first of all in production. Argentina, Brazil, India, the Republic of Korea and Turkey contributed between 40 and 45 per cent of the developing countries' production with the exception of China. Eighty per cent of machine-tool production within the developing countries concentrated within three countries: Brazil, China and India.

A second group of developing countries is made up of those which are at the embryonic stage.

The third group consists of 60 countries (actually 110 if one considers the 50 countries and territories of less than 1 million inhabitants) which have no capital goods industries and which relied mainly on agriculture.

These imbalances are also expressed within the nature of the products manufactured and the means of production. In numerous developing countries assembly lines have been introduced in the manufacture of more complicated products such as tractors, trucks and other vehicles. However, these operations are limited to assembly only, rendering minimal the value added and the industrial experience thus acquired.

These imbalances then appear within international trade. The small volume of exports from developing countries has been emphasized. The large part of this trading is carried out by Argentina, Brazil, Hong Kong, Mexico, India, the Republic of Korea and Singapore. It should be noted that in some of these countries exports are very often carried out by branches of the multinational firms which have access to direct investments.

With regard to imports, Algeria, Brazil, Iran, Iraq, Mexico, Nigeria, the Republic of Korea, Saudi Arabia and Venezuela had by themselves absorbed about 40 per cent of the imports from the developing countries in 1978. Seven of these countries were oil-producing countries. If one adds Egypt, Hong Kong, Indonesia, Liberia, Libya, Malaysia and Singapore to this list, 16 developing countries imported almost 60 per cent of the group's imports.

These imbalances also affect consumption of capital goods: Per capita consumption in the 60 essentially agricultural countries is 7 to 8 times less than that in those developing countries which have an industrial base.

The First World Consultation of the Capital Goods Industries is faced with a two-fold need: How to change the present pattern of production and the trade situation in the capital goods industries between developed and developing countries, on the one hand, and among the developing countries themselves on the other.

Future Prospects up to 2000

Lacking alternative scenarios which would necessiatate information on the projects, the secretariat of UNIDO has attempted to predict "images" of possible future occurrences up to year 2000, by using the world industrial input-output model. This model is normative with respect to the future and simulative with regard to the past (it "reproduces" past relationships), resulting in normative projections. The forecast is worked out basically so as to attain the goals of the Lima Declaration and Plan of Action as a function of the various growth hypotheses of the industrialized countries.

Two hypotheses related to the growth rate of gross domestic product within the developing countries during the period 1970-2000 respectively at 4 and 2.6 per cent have been carried out. With regard to the mechanical and electrical industries, the following results have been obtained:

(a) Production in developing countries will increase at a rate of either 11.2 per cent in the case of hypothesis 1 and to 9.8 per cent in the case of hypothesis 2;

(b) Their consumption will increase at a rate of 10.5 per cent and 9.0 per cent respectively;

(c) According to both hypotheses, local production in the year 2000 will cover 55 per cent of consumption as compared to 45 per cent in 1970;

(d) Both hypotheses give developing countries a share of between 15 and 17 per cent of world production.

Thus in both cases, reaching the Lima target of 25 per cent (which was never taken to mean 25 per cent for any specific sector), would not seem achievable. These results cross-check with those obtained by UNCTAD and are close to those in the OECD "inter-future" scenarios where the developing countries' share of world production of capital goods amounts to 12 per cent and, if China is included, this would be 16 to 18 per cent.

The secretariat of UNIDO has investigated these normative projections with regard to different groups of countries based on the second hypothesis (average annual production growth rates in developing countries of 9.8 per cent with a demand of 9 per cent), while at the same time bearing in mind the variations in this average with respect to different groups of countries.

<u>Alternative 1</u>

(a) It is those countries with an industrial base in the process of being established which improve their position the most. They represent 27 per cent of the demand of the developing countries and 22 per cent of the production (as against 23 per cent and 15.5 per cent respectively in 1977). The level of covering national demand with national production (national cover) will increase from 0.30 to 0.43.

(b) Countries with a large industrial base, such as India, whilst having improved their ability to meet national demand with national production, find their position more or less unchanged since they have become important exporters.

(c) The most underdeveloped countries which are those with an agricultural base will see their situation unchanged or possibly even made worse during this period.

Alternative 2

(a) The most underdeveloped countries will see their situation improve. However it should be observed that, even with high rates of growth, countries with an agricultural base will still provide only 3 per cent of the production of capital goods in the developing countries, 7.8 per cent of the consumption, and will have a level of national cover which will not exceed 0.20 on average by the year 2000. Countries with an agricultural base represent 28 per cent of the total population of the developing countries.

(b) Countries with an industrial base in process of being established will achieve the same results as in the previous case.

(c) India and countries with a major industrial base will see their contribution slightly reduced in the whole of the developing countries.

Role of state and planning

The rebalancing, regulation and development of the sector over the longterm require conditions which are real prerequisites. In the developing countries, the first condition is the existence of industrial, sectoral planning.

In developing and developed countries alike, the second condition is recognition of the role which the State should assume within the capital goods policy.

In the centrally planned economies, the State is directly involved in commercial transactions and in technical assistance for industrial operations. In the market economy developed countries, the State generally supports industry's export activities and sometimes assumes responsibility for the risks.

The governments of the developing countries are necessarily involved in setting up projects in the capital goods industries. This is because in many cases short-and medium-term profitability is not attractive and the initial outlay for infrastructure and training is high. Private entrepreneurs if they exist - are certainly not going into investing in these activities. Whatever juridical from ownership might take, the State can at least provide incentives and general organization and, in particular, orient the educational system and technical training. A policy for capital goods in the developing countries must have well co-ordinated initiatives; otherwise, it risks failure.

In the industrialized countries, the State could assume another function in order to strengthen industrial co-operation with the developing countries. The capital goods sector is sometimes scattered among numerous small-and medium-sized enterprises which are often active and innovative. They do not enjoy the freedom of movement necessary in order to branch out into international operations. Their participation in industrial co-operation requires organization and support from public sources. Now the natural trend of the small and medium-sized developing countries is to work with small and medium-sized enterprises rather than the large ones.

Thus, one arrives at the notion of structured bilateral co-operation within the sector, the long-term arrangements which must be defined and applied in order to meet the challenges of industrialization and development.

1.21 UNIDO documents - summary of discussions

UNIDO's submission to the Expert Group Meeting was centred on its activities in the field of capital goods1/ and preparatons for the First Consultation on Capital Goods in Brussels, 21-25 September 1981. At the same time, the paper titled "Potentialities and possible progress of the capital goods industry development in the developing countries, including the small-and medium-sized developing countries" prepared for the First Consultation Meeting was presented and discussed.

In the ensuing discussion, attention was drawn to the system of consultation, its functions, participation of developed and developing countries and co-operation among various United Nations organizations. It was stressed that in the future more attention should be paid to regional and national research and studies to supplement the present global approach as well as to study various problems common to capital goods development in the developing countries, e.g., elements of licensing agreements, model contracts, protection of infant industries and co-operation between the more developed and the less developed developing countries in the area of capital goods.

Owing to the importance of international trade flows, including those in developing countries, the existence of various barriers to such exchange, and development of capital goods industries in developing countries, it was suggested that these aspects should be analyzed and studied.

It was agreed that the three issues proposed for the First Consultation Meeting were of basic interest to the developing countries. The role of State and sectoral planning in promoting further development of capital goods and the importance and value of regional and subregional co-operation was greatly emphasized.

1/ See paper: "UNIDO Activities in the Field of Capital Goods Industries Development".

ANNEX I

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III. United Nations system and international organization

1. Economic Commission for Africa (ECA), Addis Ababa.
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IV. United Nations Economic Commission for Western Asia (ECWA) Joint ECWA/UNIDO Industry Division

1. Mr. Ribhi Abu El-Haj, Chief.
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V. United Nations Industrial Development Organization (UNIDO)

1. Mr. Farlan Carre, Deputy Executive Director.
2. Mr. L.Z. Angelov, Head, Sectoral Studies Branch.
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4. Mr. J.A. Ghani, Senior Industrial Development Officer.
5. Mrs. C. Gettner, Secretary.
6. Mrs. O. Wolf, Secretary.

ANNEX II

List of Documents

I. Documents prepared by the ECWA/UNIDO Industry Division

1. The Viability of Establishing a Regional Telecommunication Industry in the ECWA Region.

   Part 1: Basic Economic and Technological Considerations.
   Part 2: Pre-feasibility Study on the Telephone Exchanges.
   Part 3: Pre-feasibility Study on the Telephone Instruments.

2. The Viability of Establishing a Regional Electric Power Equipment Industry in the ECWA Region.

   Part 1: Basic Economic and Technological Considerations.
   Part 2: Pre-feasibility Study on Turbines and Generators.
   Part 3: Pre-feasibility Study on Transformers.

3. Establishment of Manufacturing Capacities for Fabricated Equipment for Chemical Industries in the ECWA Region - A Techno-Economic Study.

4. Establishment of Telephone Cables Industry in ECWA Region. A Techno-Economic Study.

5. Establishment of Power Cables Manufacturing Industry in the ECWA Region - A Techno-Economic Study.

6. Preliminary Study on the Viability of Manufacturing Construction Equipment in the ECWA Region.

7. Industrial Co-operation - An Alternative Long-Term Partial Industrialization Strategy.

8. Study on "Industrial Policies in the ECWA Region - An Appraisal".

9. Technology Transfer and Development Pertaining to Capital Goods Industries.

II. Documents prepared by UNIDO

1. Potentialities and Possible Progress of the Capital Goods Industry Development in Developing Countries Including the Small and Medium-size Developing Countries.

2. Technology in the Service of Development and a Strategy to Initiate/Accelerate the Capital Goods Industry Development.

3. International Co-operation Including the Long-Term Contractual Arrangements for the Setting up of Capital Goods Industry in Developing Countries.

III. Documents prepared by experts and organizations

1. The Role of EIDDC in the Promotion of Engineering Industries by Mr. Yusef Mazhar.

2. Problems and Prospects of Capital Goods Manufacture in the Third World Mr. K. Aselmann - ESCAP.

3. Development of Capital Goods and Heavy Engineering Industries in the Syrian Arab Republic by Mr. A. Sallouta.

4. Choices and Risks of Electronic Products Manufacturing in Developing Countries by Mr. Khaled Diab.

5. Co-operation and Co-ordination Among Arab Common Companies prepared by Council of Arab Economic Unity General Secretariat (English and Arabic).

6. Executive Summary of the Study for the Establishment of An Arab Engineering Company in the Oil Arab Sector by Organization of Arab Petroleum Exporting Countries (OAPEC).

7. Interlinkages Automotive, Agricultural and Construction Machinery Industries by Arab Industrial Investment Co. (AIIC).

VOLUME I

PART 3

REPORT OF EXPERT PANEL ON ELECTRIC POWER

GENERATOR AND TURBINE MANUFACTURING,

3-5 OCTOBER 1983, BAGHDAD

I. INTRODUCTION

A. Background and objectives

The Expert Panel on Electric Power Generator and Turbine Manufacturing was held in Baghdad, Iraq from 3 October to 5 October 1983. It was organized by ECWA as a part of its programme on identification and promotion of regional projects in the field of capital goods and heavy engineering industries[1/] and was specifically devoted to power generators and turbines manufacture.

The meeting was attended by:[2/]

- 2 experts from developing countries (India and Mexico) with long first hand experience of establishment of this industry in developing countries;

- 7 representatives of Arab investment and industrial development organization;

- 5 experts from electricity generation and electric power projects;

- 8 representatives of world's leading manufacturers of power generator and turbines.

In addition to the above-mentioned, the meeting was attended by His Excellency Abdul Tawab Mulla Howaish, Senior Under-Secretary, Ministry of Industry, Government of Iraq, and by a representative of the Royal Netherlands Embassy in Baghdad.

The meeting was necessitated by the desire on the part of some Pan Arab investment organizations who attended ECWA's Expert Group Meeting on Capital Goods and Heavy Engineering Industries, held at Vienna in July 1981, to further elaborate on problems and prospects of establishment of turbine and generator manufacturing industries in the ECWA region. This was considered desirable in order to enable the prospective investors to formulate the best approach to realize the projects.

Thus the main objectives of the panel were:

(a) To acquaint the prospective promotors - investors with the problems and prospects of the industry in the region;

(b) To assist these promotor - investors in formulating an approach and tentative course of action for phased establishment and

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1/ See annex 3.

2/ See annex 5.

development of the turbine and generator manufacturing projects - learning from the experience of other developing countries and from the leading manufacturers of power generators and turbines.

Of course, the second objective is a long-term one and can only be partly achieved in such meetings. It is to be borne in mind that due to inherent complexities and long gestation periods associated with such projects and due to the fact the region has practically no experience in such industries, continuous assistance to the promotor - investors has to be afforded during the promotion, establishment, development and operation of the industry.

In consultation with the promotors - investors, the following subjects were included in the identifying issues for the meeting:

(a) Standardization of product specifications and unit sizes;

(b) Commonalities of turbine and generator manufacturer and alternative approaches to integration;

(c) Analysis of manufacturing and technological requirements for major components and stages of local manufacture;

(d) Capabilities and capacities in marketing, after-sales service, design and erection;

(e) Technology transfer problems, technology packages and related issues;

(f) Phasing of project implementation including build-up of capabilities in marketing, after sales services, design, erection, production build-up and training.

B. Opening session

Since the meeting was in the nature of a highly technical panel with participants from commercially oriented firms, the panel went straight into its business without any inauguration ceremonies. The Chief of the Joint ECWA/UNIDO Industry Division introduced the objectives of the panel together with the major subjects and issues explaining the background of each.

Welcoming the participants to the permanent headquarters of ECWA, Mr. R. Abu El-Haj presented the capital goods industries programme framework within which the meeting was being held. He said that the programme, though a modest one considering the needs of the region and the complexities involved, had proved to be effective with the co-operation of the region's financial and investment institutions. That co-operation, it was hoped, would continue. The panel, which was representative of all the interests from all parts of the world, provided an excellent opportunity for formulating specific ideas about global co-operation.

The capital goods programme was aimed identifying and promoting those regional projects which by their very nature needed to be established at the regional level. The programme was aimed at establishing such projects which would lead to providing a strong nucleus with strong forward and backward linkages, including those with other regional and national projects, in order to develop technical and managerial capacities which are basic ingredients for self-sustained industrial development. The programme consists of:

(a) Identification of specific industrial projects through techno-economic studies;

(b) Promotion of those projects through national and regional investment organization;

(c) Technical assistance to investment organizations through various stages of implementation;

(d) Co-ordination with other national, regional and international organizations with similar aims and objectives.

So far a number of projects in the industry areas of chemical equipment, power equipment, telecommunications equipment and electronics and construction equipment have been promoted. The project implementation mechanisms are well established in national and regional investment organizations. Even though there is natural reluctance on the part of these organizatons to venture into projects with high complexities they have in past gone ahead with such projects after becoming convinced of their strategic nature and understanding the inherent problems well in advance.

The purpose of the panel was precisely to foresee the problems and their complexities together with their possible solutions so that the strategic projects on power generators and turbines could be implemented with minimal bottlenecks.

The issues which were identified in consultation with promotors and investors were then briefly mentioned.

The region's market size which will rise from present level of 3,000 MW to over 7,000 MW will have important bearing on scale economy. The market size will have limitation to the maximum unit sizes of the turbines and generators that can be established. The first issue for this panel was the standardization of the unit sizes in the light of practices and programmes of electrification in the region, the market and the world trends.

One of the programme objectives is to distribute the production capacities in the member countries as far as possible. However, this should not be done at the expense of scale economy or local integration. The second issue is whether turbines and generators should be manufactured in one plant or should we have a production split. Commonalities of the turbines and generators manufacture will govern decisions on this aspect.

The turbine and generator manufacture with high internal integration can only be achieved over a long period. Operations of such facilities start with assembly of imported components which have to be introduced for in-plant or local manufacture in a phased manner. For each component, scale economies, manufacturing requirements, skills build-up are the important factors for make/buy decisions and timing for their introduction for manufacture in case it is economical to do so. The resolution of this issue would give a clear picture of modalities of establishing this project.

Establishing manufacturing of facilities in turbines and generators is not by itself sufficient for the healthy development of this industry. Build-up of capacities and capabilities in power generation systems design, marketing, product design, erection and after sales are key elements for success, and it has been seen that those manufacturers who did not possess capacities and capabilities for supply of complete power houses on a turn-key basis failed to capture the market for turbines and generators.

The project will definitely require technology from one or more of the established turbines and generators manufacturers in the world and since the representatives from the most dynamic firms, General Electric, Brown Boveri, Mitsubishi and Skoda, were present the issue of technology transfer could be discussed in the light of modalities, the practices being adopted by the technology suppliers and recipients.

II. STANDARDIZATION OF PRODUCT SPECIFICATIONS AND SIZES

A. Issues

Various sizes of generating units are used in the region at present. Moreover because these equipments are procured from various manufacturers, the product specifications vary considerably. From the point of view of production economies especially for a new industry, the number of unit sizes should be limited to a bare minimum. Three sizes namely 100, 150, 300 MW for steam units and two sizes, for gas units namely 50, 100 MW have been suggested in the study.

The standardization of product specifications enhances the viability of the plant because like unit size it could affect production processes, machinery, skills, and even materials. Such specifications among others, relate to the various steam pressures and temperatures, heat flow, etc.

The users of the equipment are the electricity authorities, and they will have to decide on minimum number unit sizes and specifications which will suffice their needs and become standards.

Since this issue is a basic one in its impact on the viability of the factory, it should be resolved at the outset before a feasibility study is conducted.

B. Discussions summary

The experts confirmed that the proposed 100 MW, 150 MW, and 300 MW sizes for steam turbines and the 50 MW and 100 MW sizes for gas turbines are best sizes for ECWA countries because of the following considerations:

(a) From the manufacturing point of view, the skills and material requirements needed for producing unit sizes larger than 300 MW become very stringent. The difference in the cost of machinery capable of producing unit sizes up to 500 MW relative to 300 MW does not exceed 20 per cent.

(b) From the operational point of view, the present national networks can not absorb large unit sizes. As a rule of thumb, the largest generating plant should not exceed 10 per cent of installed generation capacity in a country.

The experts pointed out that standardization of unit sizes in the factory affects generators and not turbines because the physical size of the generator is a function of generator output while turbines are built in modular concept.

Moreover, standardization should not be restricted only to unit sizes but rather to the entire plant including steam conditions.

The experts emphasized the fact that standardization positively affects cost of spare parts, dimensioning of various parts and allows the attainment of higher local integration levels.

III. COMMONALITIES OF TURBINE AND GENERATOR MANUFACTURE AND ALTERANATIVE APPROACHES TO INTEGRATION

A. Issues

Steam and gas turbines by technology are items of mechanical equipment but traditionally these are supplied by electrical equipment manufacturers as major components in complete power generating plants. The manufacture of steam, gas turbines and generators is undertaken under the same top management and in many cases in the same factory. This is because manufacturing linkages are quite strong. It entails utilization of floor space, material handling and other common facilities within the factory. It also entails the utilization of major machinery and skills required for the manufacturing. In fact, some of the large machining facilties, such as heavy duty lathes, milling machines, vertical and horizontal bores, would be common for the components of both turbine and generator.

The technology and the manufacturing techniques for the gas turbines have some distinct variations from the steam turbines. The manufacturing equipment for the gas turbine must be specially set up as the turbines have more precision. However, the generator coupled to a gas turbine is nearly the same steam turbo-generator except that the former is smaller in size. Several options exist with regard to establishment of the projects.

The entire manufacturing facilities could be established at one location forming one single operation and the entire investment would be made at one place. In this case the investment may be the lowest, but the size of the establishment will be large and will require a high order of managerial skills. Furthermore, a large base of skilled manpower and infrastructural facilities at a single location will have to be created. This arrangement will facilitate easy planning during operation of the plant and proper co-ordination of after-sales problems. Handling of varied technologies, for different products, at a single location may also create its own problems.

The second option may be to establish facilities at one location but under different roofs. Such a set-up would call for higher investment but some operational costs could be reduced by pooling some services such as material purchases, stores and other common services.

The third option may be to spread the manufacturing facilities around different locations; thus different countries would benefit from their establishment. But in this case the investment would be highest and co-ordination at all stages would be difficult.

These are only very few examples and there may be many other combinations of production facilities for turbines and generators.

B. Discussions summary

The experts examined the commonalities in manufacturing of steam turbines, generators and gas turbines with respect to utilization and loading of major equipment such as heavy duty lathes, milling machines and borers as well as the extent of utilization of different shops such as stamping shop, heat treatment facilities and heavy and light fabrication in the manufacturing process.

Patterns for the establishment of manufacturing facilities were also discussed within this issue. These were:

(a) Single location;
(b) Dispersement of facilities in different countries;
(c) One country but separate shops.

Some experts voiced their opinion that in view of the suggested capacity of the plant, namely 3,000 MW per year, which according to them is considered to be on the lower side, it is advisable that all facilities for manufacturing of steam and gas turbines and generators will be established in one location and under one management. Within this arrangement the manufacturing of gas turbines will be integrated with the manufacturing of steam turbines and generators, which will lead to better utilization and proper loading of expensive equipment which will be installed in the plant.

The possibility of dispersing manufacturing facilities in different countries was discussed. This alternative pattern stemmed from the context of interlinking the manufacturing facilities among the countries in the region and thus the benefit of developing this industry in the region could be shared by all parties. Several experts were against this pattern of establishment and particularly with respect to separating the manufacturing facilities for turbines and generators. Many experts agreed that the manufacturing facilities for these two items should be kept together, for easy co-ordination in various stages of production as well as for the purpose of common testing, in addition to other advantages such as proper utilization of common equipment and shops. One expert pointed out that separation of manufacturing of turbine and generator has been practised by one country, but this has faced many problems and difficulties.

Further discussions were carried out on the extent of manufacturing 50 MW gas turbines within same facilities. Several experts confirmed that many components of gas turbines of this size could be manufactured within the same facilities. As for the specialized components of the gas turbine, these will be manufactured by special equipment.

The pattern of establishing all the facilities in one location was also discussed from the angle of building up skills and capabilities in manufacturing. Many experts spoke of the advantages which will be gained from putting all the facilities in one location.

The equipment and method of testing were discussed. It was pointed out that the testing as well as quality control procedures will be required during various stages of production.

IV. ANALYSIS OF TECHNOLOGICAL AND MANUFACTURING REQUIREMENTS FOR MAJOR COMPONENTS

A. Issues

The third issue relates to gradual build-up of manufacturing capacities for various components. Turbines and generators can be considered as custom-made machines. Virtually, there is no mass production activity and batch production is limited to a few standardized smaller components. Design of various elements in the turbines and generator may have to be changed - rather frequently. General purpose heavy machine tools with good flexibility, easy of adaptability and low tooling costs are characteristic of such plants. Yet due to their size and sophistication introduced in the recent past through computerized numerical controls, the cost of such machine tools is very high. These machine tools may be installed in the plant in a phased manner as the work load develops.

The build-up of skills in design, tooling and manufacturing operations is another direct factor that must be considered along with scale economies to decide the timing of introduction of various components for in-plant manufacture. Additionally, introduction of a production process at a particular time, or in other terms the manufacturing equipment, has to take into consideration the commonality of manufacturing operations among various components.

Indirect factors may include the proprietary nature of design and manufacturing technologies for certain components. Limited availability of technology may lead to postponement of in-plant manufacture for these components till internal technological capabilities are achieved in the manufacturing enterprise.

Most components undergo different manufacturing operations to the stage of their finished form. Sometimes, it is more economical to have some of the process operation carried out through subcontracting. Additionally, it may be more economical to buy the components in their intermediate stage and then to machine finish them. Reliability of supply sources, including quality, timely delivery and price, are the factors to be weighed against the costs entailed in in-plant manufacture.

Such subcontracting decisions are critical in the plants with job order characteristics like turbine and generator manufacture. In spite of all the problems likely to be encountered in the establishment of turbines and generator manufacture and in build-up of capacities and capabilities, the enterprise should aspire to achieve a high degree of internal value added without causing undue strains on limited managerial resources and without impairing quality of products.

At this stage it is not intended to go into the details but for major components of turbines and generators, the following questions will arise:

(a) What are the materials of the components? Is the supply of these materials controlled by a limited few?

(b) What are the practices with existing manufacture in regard to the form in which the component is procured, namely forging, casting or semi-machined? Are the supply sources limited?

(c) Is the component a proprietary item or does it have limited source of technology? What are the sources of this is so?

(d) Is the component bulky, thus entailing high cost of transportation?

(e) What are the capital goods required? Are these expensive?

(f) Can the component be designed and manufactured on a modular basis?

(g) In what time frame should it be introduced for local manufacture? Should it be in the main plant or can it be locally subcontracted?

(h) How was build-up of capacities achieved in recently established ventures in Europe, India, Brazil and other places? What are the planners envisaging in the ventures being established for the near future?

B. Summary of discussions

These issues were raised, as the main objective of this panel was to set a course of action in realizing the project in a smooth and effective manner. A number of questions were raised. However, due to various reasons the discussions centred around laying down the criteria for the manner of building up local integration. The criteria suggested by one manufacturer included:

- Size of the components;
- Investments;
- Value added;
- Complexity;
- Combination of processes;
- Task of technology transfer.

The same manufacturer suggested the establishment of a fabrication shop first for LP cylinders with associated machining centres and explained the details regarding various manufacturing equipment. HP cylinders can also be taken up to manufacture at about the same time if the procurement skills for normalized castings are available. In the second stage, rotating parts should be taken up for manufacture from small ones to large ones. In the third stage, rotor machining from bought out forgings should be carried out. Owing to heavy weight, captive forging facilities will not be economical. The rotor requires over speed test runs, the installation for which is very expensive and the skills are difficult to master. These and other testing facilities should be established in the initial stages, as considerable effort and time go into their design, procurement and installation. The same expert spelled out different technologies for rotors and gave functional details and manufacturing and technological requirements for other critical items such as governors main steam values, safety devices,1/ rotors etc.

The experts concluded that gas turbines, which require different materials of construction and therefore partly different manufacturing technologies, can be manufactured in the same plant due to their commonality with steam turbines with regard to heavy machining.

On the generator side, hydrogen cooling vs. water cooling of generators was discussed. Though the manufacturers have different practices, the cut-off limit for hydrogen cooling may be set at 300 MW. This will have a bearing on design technology.

Generator manufacture phasing should also be on similar lines to turbines. Static parts should be taken up for manufacture first and rotating elements later. Stator and rotor should be bought out at initial stages. Then complete stator manufacture from the raw materials stage should be undertaken. This is due to the fact that handling of coils in transport is very delicate and as such no manufacturer in the world buys these out. As against turbine manufacture which is machine intensive, generator manufacture is more labour intensive. Winding methods are usually proprietary techniques and each manufacturer has his own methods.

The build-up of production will be from the small sizes, but it will be prudent to design the buildings with provisions for higher sizes, for example, hook level for the largest size of generator to be produced and large cranes to be added later.

The plant should be located at a site which will afford easy transport of heavy products. It should have its own terminal facilities.

The future of excitation technology was discussed and it was concluded that static exciters will be increasingly used in future. As such it will be quite easy to start manufacture of this part in the first or second stage.

1/ See flow diagrams in appendix.

V. CAPABILITIES AND CAPACITIES IN MARKETING, AFTER SALES SERVICE, DESIGN AND ERECTION

A. Issues

The market for power turbines and generators consists of, mainly, electricity authorities and utility companies. Another major characteristic of the industry is the custom-designed nature of its products which are, in general, very large units. Hence the programming of overall production is rendered extremely difficult by the irregularity of orders and the size of each individual order. It seems, therefore, that the principal factor to achieve success is to secure enough orders and spread them uniformly so as to keep the production facilities well utilized. This could be fulfilled if the electricity authorities and utility companies establish long-term plans for a 10 to 15 year period giving the estimated composition of their future equipment requirement. This would also permit the manufacturer to invest in expensive production facilities and to go ahead with production planning and supplier contracts. It follows that if the proposed facility fails to secure an adequate volume of orders then it may be uneconomical.

The practices in ECWA region with regard to implementing power plant projects are, by and large, classical. In most cases, once the decision has been taken on the basis of previous studies, bids for carrying out engineering services are invited from the consultants. Such services normally incorporate:

- Site investigation
- Economic evaluation
- Design and engineering
- Specification and tender documents
- Tender analysis
- Supervision of construction, start up, testing, training and guarantee tests.

When contracts are awarded on a turn-key basis, some of the engineering services are provided by the bidding contractors before submission of their bids. In that case project costs tend to be higher, but the owner is relieved of the effort that has to be made in co-ordination of the projects during the preliminary stages.

If the basic engineering services are provided by the consultants, tenders are invited for either supply of complete plant or plant sections. Based on this basic engineering and specification, the engineering departments of the manufacturer has to prepare design drawings, shop drawings and erection drawings. In view of this, it may be necessary to build up engineering capabilities within the manufacturing establishment to carry out necessary engineering services required for the contract performance of the power projects. In addition, capacities for absorption of manufacturing technology and for overall operation of the manufacture of product are necessary. At the same time, it may also be essential to develop consulting engineering the capabilities, in addition to the manufacturing established on a regional basis, to handle the services normally required from the consultants or to supplement/complement the engineering services normally carried out now by some regional electricity authorities and utility companies.

The customer in many cases requires the inspection of equipment to be carried out by a recognized inspection agency to ensure that it conforms to the laid down standards and specifications. This, however, does not relieve the manufacturer from the responsibility of warrantees in regard to materials and workmanship. Building up inspection facilities, on a regional level, independent from the manufacturing facilities is important for the sake of quality assurance.

Capabilities have to be built up to enable the manufacturer to undertake complete responsibility of erecting the supplied equipment at site. It is preferred that the supplier of the equipment carries out complete erection in order to avoid splitting the responsibility and delays in completing the work. Very close links exist between the erector and the manufacturer for carrying out immediate and necessary modifications, alterations and additions in the course of erection without any delay.

Some defects in material and design of equipment may come to notice during the operation of the power plant. Such defects can only be remedied by the manufacturer since they possess the requisite technical know-how. Therefore, building up capabilities to attend to major breakdowns is quite essential for the manufacturer, as it will provide the manufacturer with feedback on performance of the equipment.

B. Summary of discussions

Several points were discussed within this issue, namely:

- Marketing
- Plant System Design Capabilities
- Plant Erection Capabilities
- After Sale Services.

With regard to marketing, the representatives of electricity authorities confirmed that long-term plans with regard to power demand and network expansion are normally prepared by many electricity authorities in the region. These long-term plans give the number and size of the generating units to be installed in future. Accordingly the manufacturer could establish its production plans to suit the authorities' long-term plan. It was pointed out during the discussion that, since the suggestd manufacturing facilities at maximum production represent only 50 per cent of the annual demand of the region, the market could be penetrated with less difficulty.

The importance of building up capabilities related to power system design was elaborated and discussed in detail. Many participants indicated that this was very essential because the purchase of power plants in the region was made on a turn-key basis. Some participants suggested that the proposed turbine-generator manufacturing enterprise should get into joint ventures with manufacturers of boilers in order to ensure and secure the orders for complete powerhouses.

The Indian experience in setting up power system capabilities was reviewed. It was emphsized that the key to the success of this industry in India was due to setting up of this capability, because it was very difficult to sell only turbines and generators as individual equipment. The difficulties of some Western manufacturers in keeping up in the market due to lack of power system design capabilities was highlighted as an example of the importance of building up this activity. The provison of erection capabilities within the manufacturing facilities was discussed and its importance was emphasized by the participants. Some suggested that an agreement could be made with some foreign companies or with local ones, if there were any to carry such services on behalf of the local turbine-generator manufacturer. This capability, however, should be created at early stages of the development of the industry. Some other participants suggested that such services could be established at any time, independent of the development of the industry.

The importance of after-sale service and provision for spare parts for manufactured equipment was emphasized by the participants. It was pointed out that this will effect penetration into the market. The state of the market in the region was reviewed and it was indicated that almost all leading international manufacturers had strong after sales service representation in the region. To be competitive, this activity has to be developed properly. Some participants suggested starting these services in joint venture with some foreign manufacturers.

The manufacturers' representatives indicated that the activities related to marketing, power system design capabilities, erection and after sales service could be provided by the foreign company who provides the know-how to the local manufacturer in "Block-System". The extent of these services depends upon on the type of the agreements, which will be made by the two parties. The manufacturers' representatives warned of difficulties in having so many things at the same time in an infant industry. They suggested that priorities be established and phasing of implementation be followed accordingly.

VI. TECHNOLOGY TRANSFER AND PACKAGES

A. Issues

The issues related to technology acquisition, adaptation and adoption to be able to design, manufacture, sell and service turbines and generators are included in this group. The importance of building capacities in some of these areas has been amplified earlier. Here it is intended to discuss how to master these arts in order to be able to satisfy the requirements of the market with a good degree of confidence.

The technology transfer starts in any manufacturing establishment at the very planning stage. The plant facilities to be acquired for the establishment are linked to the product design. Even though turbine and generator manufacture uses, by and large, standard or at best automated flexible manufacturing systems, the established manufacturers have developed their own manufacturing tools and techniques. Generally, the consulting engineering firms assist in basic engineering of the plant facilities in the engineering industry but the nature of the products may dictate the necessity of involvement of the supplier of product design and product technology. The first question to be raised is whether the basic engineering of production facilities should be carried out by consulting firms or by product technology suppliers. If both have to be involved, what is the extent of their involvement? This question has to be discussed with special reference to non-standard production equipment such as test beds etc., usually developed by the manufacturers. After first phase construction, the plant facilities shall of course be built in a phased manner, in continued consultation between the recipient and suppliers of technology.

This raises another issue: Should product technology suppliers be tied up first or should they acquire the first set of product designs and drawings and then have the plant designed around these product designs or should production facilities be designed first, acquiring and adapting the product designs later?

For each product and each of its components not only the drawings and specificatons will be necessary but the process engineering for manufacturing as well as the design methods will also be required. Ultimately, skills in this field have to be acquired to the stage of self-reliance. What documentation and other software should accompany the initial technology supply agreement and how these skills should be acquired is yet another issue.

Barring a few exceptions, turbines and generators are being manufactured by the same companies. Should the product design and manufacturing technology for both be acquired separately from different sources? Different practices have been adopted for supply of designs depending upon the level of technological attainment. Will it be necessary to acquire the designs of technological attainment. Will it be necessary to acquire the designs each time a customer approached the proposed establishment for supply of turbine or generator? How can this be phased out and in what time frame? Earlier in the discussions, it was concluded that the proposed enterprise should manufacture three basic sizes namely 100 MW, 150 MW and 300 MW. Keeping in mind that the higher sizes will be introduced later, will it be appropriate to acquire product designs for the three sizes together?. This will cost much less than if the higher size, namely 300 MW product design, is acquired later. The advantage of acquiring some product designs later will be that the latest and most efficient designs will be available.

Many CNC[1/] machine tools will be deployed amongst production facilities. Will it be appropriate to acquire the software for these, after supplying the manufacturing drawings to the machine tool suppliers or will the software developed by power equipment suppliers be necessary? It may be mentioned that the machine configuration for machining centres may be different than those possessed by the technology suppliers. How long does it take to master process engineering including development of software skills?

What is the trend amongst technology suppliers in regard to equity participation in new ventures in developing countries? It is learnt that some time IEA[2/] lays down basic policies in this regard.

The industry is quite competitive and as such manufacturers have their elaborate R&D facilities, entailing heavy recurring expenditure. How much is his R&D expenditure in relation to value of output? What are usually the terms and conditions for cross licensing of the innovations? Are the cross licences given on exclusive rights or is the first recipient restricted not to sublicense to his licensee?

Other elements of technology package for turbines and generators will include:

- Materials management including specifications, purchase methods, pricing information, vendor development, etc.;

- Quality control procedures including incoming materials and intermediate quality assurance, in-process quality controls, final testing of generators and turbines, quality assurance procedures for systems, etc.;

- Production management including scheduling and control;
- management systems;
- Marketing and pre-sales service;
- Training for erection procedures and after sales service;
- Power systems design.

1/ Computerized Numerical Controls.
2/ International Electrical Association.

The path of relatively less resistance is to involve the technology suppliers in equity participation heavily but this leads to another set of problems which are not the subject of the discussions in this session.

B. Summary of discussions

Because a number of important questions were raised in the presentation of issues relating to technology transfer in turbine and generator manufacture, the participants desired that each of the questions should be discussed separately even though they are closely linked. Another suggestion was made that first the technology packages be identified from an overview of technical collaborator's obligations and then individual questions should be analysed.

The technical collaborator's major obligations were identified by some participants to be as follows:

(a) Precise market survey;

(b) Training and basic design of training facilities and programmes;

(c) Design of plant specially layout and identification of and governing specification of production equipment;

(d) Design and drawings including shop floor drawings for products; design methodology and data must be included;

(e) Specifications of materials and intermediates, sources and pricing and other aspects of vendor development;

(f) Warrantees on design and performance of products;

(g) Initial manpower - engineers, technicians for training;

(h) Long-term update of technology;

(i) Production process charts operation sheets and NC software;

(j) Quality control manuals.

The envisaged plant is not only to cater to the new demand originating from expansion of generating capacities but also that from replacement of used up production equipment and from modernization programmes in powerhouses. The replacement demand will be quite significant and for its assessment the technical collaborator's expertise will be essential.

Careful formulation of training programmes including identification of starting qualifications of trainees, the ultimate skill achievements for various jobs, software needs and hardware needs; number and type of training staff required etc. will go along way towards the success of power generation equipment manufacturing. Usually, in developing countries where a start is being made for establishment of this industry there are no sources of getting trained manpower. In these countries, the training facilities can represent the power generation equipment manufacturing plant on a miniature scale. In other words, small industrial turbines - steam and gas- as well as small generators are manufactured in the training facilities and large ones in the main plant. This approach leads to the concept of productive training.

The necessities for capability for power systems and equipment design need no further elaboration. The technical collaborator's obligations not only include supply of design and manufacturing drawings but also to see that, in time, capabilities are created both in terms of adequate reference documentation as well as trained personnel to undertake, independently, complete design of systems, turbines, generators and their components. Assessment of CAD and CAM capabilities in the collaborator's organization and his willingness to part with the software and to train design personnel should be major criteria for his selection as a partner.

The technical collaborator has to participate with the consultant in developing layout of the plant and identification of major equipment. The identification of major production equipment should be based on analysis of various alternatives at least in expensive equipment and should have sufficient source flexibility for the main owner.

Likewise supply sources for materials, intermediates and bought out components have to be multiple. The collaborator's responsibility includes vendor development in association with the owner and he as to divulge the information on alternative specifications, sources, prices and purchasing practices.

A comprehensive system of warrantees on designs and quality assurance will have to be evolved and agreed upon. The warrantees, in simple terms, will include performance of systems and individual pieces of main equipment, auxiliaries and components manufactured according to the collaborator's designs as well as those manufactured to the designs evolved in the envisaged plant with the assistance of the collaborator. Ensurance of guarantees will be the most difficult part of the know-how agreement in terms of formulation and negotiations. Suitable mechanisms, which should include expertise of persons who have already participated in such agreement negotiations on behalf of the owner, shall have to be evolved.

Some of the above aspects, particularly the design technology, are linked to consistent update of technology. Although the likelyhood of future developments which could significantly lead to obsolescence of the manufacturing facilities is little, the development will, for sure, lead to improvements in product performance as well as in cost savings. Both of these factors will affect the competitive standing of the manufacturing organization unless a constant update of technology is ensured. There are, at present, prevalent practices of cross licensing of innovations amongst the major manufacturers of power generations equipment in the world. Even the prospective technology supplier will be receiving such licences from others. However, this exchange of licences, takes place amongst the 'equals' placing the weak power equipment manufacturers from developing countries at a disadvantage. The least that can be done is to evolve mechanisms, and modalities to ensure:

(a) That prospective technology supplies passes on the technological innovations originating from his own organization for the use of the recipient of technology;

(b) That there are no restrictions imposed by the technology supplier on the Arab recipient of power equipment manufacturing technology in acquiring technology of latest innovations from third parties.

Additionally, the technology supplier shall have to constantly keep the recipient informed of the latest in the innovations and participate in the recipients' evaluation of such innovations.

The documentation of a manufacturing technology should include detailed flow process charts, operation sheets, jig and tool designs, predetermined motion and time standards for all components and sub-assemblies. It should also include initial supply of software for NC and CNC machine tools. The plant owner has to ensure that he receives very detailed documentation and computer software for manufacture of critical components such as turbine and generator rotors, HP, IP and LP casings, generator frames, bearing blocks, governors, generator coils, etc.

Transfer of mandatory as well as company level quality assurance systems including information and detailed manuals is in the interest of the technology supplier, the technology recipient and the purchaser of the end products. Additionally the final and intermediate in-plant testing of turbines and generators requires elaborate test beds, pits and tunnels which belong to the non-standard equipment category. The technology supplier has either to participate in the design of such facilities with the consultant or has to supply these designs under monitoring of the consultant. In both cases, the owner's engineers have to be involved in a participative as well as in an overseeing capacity. The practice of in-factory steam testing of steam turbines is no longer prevalent. Likewise the generators are not tested on load conditions in the plant. Only simulation types of tests are carried out on the manufacturer's works. This implies that:

(a) In plant simulations tests have to be very rigid;

(b) The test run procedures and initial instrumentation to test turbines and generators at the buyer's powerhouse have to be supplied by the technology supplier;

(c) All the testing facilities should be geared to the envisaged upper limit sizes i.e., 500 MW.

It was contended that the participation of a firm of consutants and the technology supplier will be necessary for design of and establishment of the manufacturing facilities for power equipment. This is so because neither of the two will possess complete facilities and capabilities for this purpose. The supply of technology would be tied up first and them the engineering consultants can be engaged. Alternatively a consortium approach can be adopted.

Different views were expressed in regard to multiplicity of licensing sources for technology. Participants from the manufacturing companies were of the view that the design technology for all products should be acquired from the same sources. This will attract good foreign manufacturers to the project. Further it will eliminate the problems for the owner to deal with many collaborations during pre and post operation periods. The technology suppliers for industries, where cost of R&D is high, do not like to see the information on their technology being divulged to their competitors and as such they would generally not accept the presence of other suppliers unless the design and manufacturing facilities are physically separated. This separation if accepted will not be economical for the manufacture of power generation equipment.

On the other side the participants from power generation and power project authorities as well as the investment organizations were of the view that tying the technology to a single source will lead to inflexibilities which will harm the interest of the proposed enterprise. A foreign manufacturer may be strong in steam turbine manufacture but he may not be so in generator manufacture and vice versa. Gas turbines are manufactured by many independent manufacturers. There may be strong and varied preferences of the generation authorities in favour of certain manufacturers. The single source tie up may also lead to delays in development of local technological capabilities.

It was suggested that a detailed analytical exercise encompassing the views of power generation authorities, the experience of successes and failures of the countries which have established this industry and the views of the investment organizations would be necessary before deciding on technology policies of the proposed establishment.

India adopted a policy of physical separation (though not rigid) of facilities for multiple licensing which were at times changed after their expiry. They also have an umbrella type agreement with a German firm for products for electric power generation, transmission, distribution and utilization. The Republic of Korea is adopting a policy of flexible multiple sources for technology. Likewise Mexico is looking for varied sources for their turbine manufacture, the choice being primarily left to the single authority for power generation in the country. Brazil has subsidiaries of large power generation equipment manufacture - the approach of single source for a single plant is self-evident.

VII. PHASING OF PROJECT IMPLEMENTATION

A. Issues

Many of the activities included in the implementation of the project and their phasing were discussed in the previous issues. Here, discussions centred around giving the overall phased implementation of the project, starting from the time when all elements of the project would have been specified and contractual agreements made between the management of the company and the collaborating manufacturer.

According to the ECWA study, the implementation of the project will move from the preproduction phase into the production phase in 4 years. During this phase, many preparatory activities will take place including recruitment of key personnel, selection of candidates for the training programme and initiation of that programme. Also included in this phase will be the construction of most factory facilities, procurement of the bulk of machinery and equipment, procurement of material supplies and formulation of production plans. By the end of this phase, the factory will have capabilities in marketing, production planning, manufacturing, quality control and administration.

The project moves into the production phase in the fifth year, and 9 years later the factory will be able to manufacture the entire planned capacity which is 3000 MW.

The building up of capabilities in this phase will be mainly influenced by the learning time. Production output in the first year of production will by only 300 MW which is 10 per cent of the planned capacity. On the other hand the major part of the manpower will be already on board at that time and will be undergoing various types of training. Between the 1st and 4th year of production, the largest unit size will be 100 MW. The 150 MW units will be produced starting on the 5th year of production, and finally by the 8th year the 300 MW unit will be produced.

Component localization will move from about 30 per cent by the end of 4th year of production to 80-90 per cent at maturation.

In-plant capabilities in erection, commissioning and after sale servicing will be available by the time the first unit is produced. Another capability which should be established at that time is product development which will be gradually built into an R&D capacity.

B. Summary of discussions

The experts concurred with ECWA's proposed implementation shedule as presented in the issue paper and in annex IV for the project, and having discussed the various elements of implementation under previous issues, they pointed out that certain activities which supposedly will take place in the preparatory phase ought to start before that.

Acquisition of technology and negotiations on agreements are activities which ought to start 2 years before the preparatory phase.

ANNEX 1

AIDE-MEMOIRE

EXPERT PANEL ON ELECTRIC POWER
GENERATOR AND TURBINE MANUFACTURING

1. Background and objectives

ECWA's study on Electric Generation Equipment mainly covers market and within this market framework the viability of turbine generators manufacturing has been established. Though some recommendations on how to realise the establishment of this industry in a phased manner have been made in the study, it is felt to be necessary that this aspect be elaborated in detail because of the complex nature of this industry. The expert panel and the background papers prepared by experts attending the panel will therefore analyse all the elements of turbine and generator manufacture, the complexity levels and economics of scale for each major component and supporting institutional infrastructure necessary for this industry. In the end the panel will recommend an action-oriented programme to realise the projects in the shortest period but in an economic and smooth manner. Particularly all the problems likely to be faced and possible solutions in technology procurement, adaptation and assimilation shall be highlighted. The experience of developing countries who have developed this industry and the views of the established manufacturers on possible improvements in technological routes adopted by these developing countries in the light of conditions in Arab countries will perhaps give the lead to answering as to how to establish this industry in the region. The panel is primarily meant to assist prospective promoters of the project.

2. Subjects to be covered in the meeting

The following aspects of the development of turbines and generators are to be covered during this meeting:

(a) Standardization of product. Specification and unit sizes;

(b) Commonalities of turbine and generator manufacture and alternative approaches to integration;

(c) Analysis of manufacturing and technological requirement for major components and stages of local manufacture;

(d) Capabilities and capacities in marketing, after sales services, design and erection;

(e) Technology transfer problems, technology packages and related issues.

(f) Phasing of project implementation including build up of capabilities in marketing, after sales services, design, erection, production build up and training.

3. Panel members

(a) Three experts with specific long experience in development of this industry in developing countries (India, Brazil, Mexico);

(b) Three experts from electricity authorities in the region;

(c) Representatives of manufacturers of turbines and electric generators - General Electric of USA; Brown Boveri of Switzerland; Japan and one company from a centrally planned country;

(d) Arab Development and Finance Organizations:

- Gulf Co-operation Council.
- Arab Industrial Investment Company.
- Arab Industrial Development Organization.
- Arab Fund for Social and Economic Development.
- Arab Investment Company.
- Jordan Pension Fund.
- Specialized Institute for Engineering Industries.

4. Duration and time: From 3 to 5 October 1983.

5. Venue of the meeting: The meeting will be held in the Conference building at ECWA Headquarters - Baghdad.

6. Cost coverage: ECWA will provide the consultants from developing countries and experts from the electricity authorities in the region with economy class, prepared round-trip tickets, from the city of residence to Baghdad via the shortest flight route, additional to UN per diem for the duration of the meeting. The Manufacturers of Turbines and Generators and the Arab Investment Organizations and other participants will bear their own expenses. Conference services and transport services shall be provided by ECWA.

7. Communications:

For communications with ECWA:

UNECWA Baghdad
Attention:

Mr. R. Abu El-Haj
Chief, Joint ECWA/UNIDO Industry Division
Telex: 213303 or 213468 UNECWA IK
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ANNEX 2

AGENDA

<u>3rd October 1983</u>

<u>Opening session</u>

9:30 to 10:00	- Opening Address - Project Background and Issues (R. Abu El-Haj)
10:00 to 10:30	- Break

<u>Session 1</u>

10:30 to 11:30	- Review of ECWA's Study on Power Equipment Manufacture and Introduction of Issue 1. (Kamil Jabbar) "Standardization of Product Specifications and Unit Sizes". - Discussions on Issues 1
11:30 to 11:45	- Break

<u>Session 2</u>

11:45 to 13:30	- Continuation of Discussions on Issue 1

<u>Session 3</u>

17:30 to 19:30	- Introduction of Issue 2 (Najim Kassab) "Commonalities of Turbine and Generator Manufacture and Alternative Approaches to Integration". - Discussions on Issue 2

4th October 1983

Session 4

9:00 to 11:00	- Introduction of Issue 3 (Ashwani Narula) "Analysis of Manufacturing and Technological Requirements for Major Components and Stages of Local Manufacture". - Discussions on Issue 3
11:00 to 11:30	- Break

Session 5

11:30 to 13:30	- Continuation of Discussions on Issue 3

Session 6

17:30 to 19:30	- Introduction of Issue 4 (Najim Kassab) "Capabilities and Capacities in Marketing, After Sales Service, Design and Erection". - Discussions on Issue 4.

5th October 1983

Session 7

9:00 to 11:00	- Introduction of Issue 5 (Ashwani Narula) "Technology Transfer Problems, Technology Packages and Related Issues" - Discussions on Issue 5
11:00 to 11:30	- Break.

Session 8

11:30 to 13:00

- Introduction of Issue 6 (Kamil Jabbar)

  "Phasing of Project Implementation including Build up of Capabilities in Marketing, After Sales Service, Design, Erection, Production Build up Training"

- Discussions on Issue 6.

Closing session

13:00 to 13:30

- Recapitulating of highlights of the Meeting (R. Abu El-Haj).

ANNEX 3

RESUME OF ECWA PROGRAMME ON IDENTIFICATION OF CAPITAL GOODS INDUSTRIES

I. Project objectives

This ongoing programme aims at the development of an integrated long-term regional pre-investment programme for the development of capital goods and heavy engineering industries, with strong linkages with related national industrial facilities. On one hand the programme should be of sufficient "mass" for providing the nucleus needed to develop industrial capacities and technological and managerial capabilities in the field of engineering industries to bring the countries concerned to the take-off stage and provide the dynamic and flexible instrument for effecting future changes in this important field. Another important objective of this programme is that it should attain a balance in the number and types of projects for achieving an equitable distribution of benefits to be derived by participating member States.

II. Project description

This continuing project includes:

1. Identification of specific industrial projects through preparation of pre-feasibility/techno-economic studies, which apart from examining their viability also include analysis of critical factors like technology transfer, institutional infrastructure, investment, finance, manpower development, standardization, location, etc.;

2. Promotion of these projects through national and regional investment organizations;

3. Assistance to the national and regional investment organization in various stages of implementation;

4. Advice to governments on practical steps needed to be undertaken for promoting national projects as regional projects. These include convening of expert panels as and when needed;

5. Technology transfer in the field of capital goods industry.

III. Progress to date

1. Studies

The following projects were identified as potential candidates for regional co-operation and pre-investment studies for them were completed by ECWA.

(i) Telephone cables
(ii) Power cables
(iii) Electronic telephones
(iv) Telephone instruments
(v) Fabricated static chemical equipments
(vi) Electric generators, steam and gas turbines
(vii) Power transformers

The above projects were the subject of deliberations in the Expert Group Meeting on Capital Goods Industry in the ECWA Region, organized by ECWA in Vienna in June 1981. They were endorsed by the meeting as candidate priority regional projects.

Apart from above a number of papers were prepared on the subject.

Studies under preparation

(a) Pre-feasibility studies on switchgear and power boilers are under preparation. Consultants' reports on these projects have already been received and evaluated. These will form part input for the pre-feasibility studies being prepared by the Industry Division's staff. These studies will examine the viability of the projects, analyse all critical factors and list experience of other developing countries in the respective subjects.

(b) An over-view study on potentials of electronics, especially the micro-electronics industry in the ECWA region is being prepared. This will form the background paper for an expert group meeting on which basis a programme of action including identification of potential regional projects will be formulated.

(c) Formulation of project on Master Plan for Technology Development in Capital Goods industry shall be carried out. The project will be submitted to potential donors for financing.

(d) Automotive industry covering passenger cars, commercial vehicles, construction equipment, agricultural and industrial tractors is a vast one and needs step by step approach. A number of countries, especially Iraq, have been contemplating entering this field. ECWA's programme in this field includes making contacts with national project authorities in order to co-ordinate development of this industry on regional basis. Additionally, a preliminary study outlining the market, the part size and strategy for development of the industry is being prepared.

2. Technical assistance and other activities

Technical assistance is being rendered to various national and regional organizations on formulation of projects in engineering industry and on diagnosis of problems faced by the operational industrial units.

Advisory services are being rendered on continuing basis not only on the implementation aspects of the projects identified by ECWA but also on other projects being implemented by the regional and national organizations. Some of these projects receiving assistance including a large foundry, a timber industry complex, seamless pipes, tyres, machine tools, ductile iron pipes, fractional horse power motors, etc.

3. Promotion

As a result of the Joint ECWA/UNIDO Industry Division's efforts, most of the identified projects have already been promoted as good candidates for investments as indicated under:

(i) Telephone cables
(ii) Electronic telephone exchanges
(iii) Electric turbines and generators
(iv) Power transformers
(v) Fabricated chemical equipment.

Efforts will be made:

(a) To promote projects on manufacture of switchgear and power boilers;

(b) To identify those projects currently being undertaken at national level and having the potential to cover regional markets - the important ones being intermediates such as foundry and forging units;

(c) To find ways and means to promote these national projects at regional level.

ANNEX 4

REVIEW OF THE ECWA STUDIES ON TURBINES AND GENERATORS

1. The major aspects of the study are the following:

(a) Examination of the status of the region's networks and equipment, as well as the planned (or expected) projects in order to determine trends relating to future types of generation, unit sizes, etc.;

(b) Projections of the growth of installed capacity and accordingly the growth of demand for various equipment;

(c) Examination of the basic characteristics of the power equipment industry;

(d) Examination of existing power equipment industries in the ECWA region;

(e) Description of the envisaged regional industry and the linkages which it must develop with the Governments and electricity authorities in the ECWA region as well as international manufactuers of power equipment;

(f) Formulation of criteria for selection candidate products for the regional industry;

(g) Prefeasibility analysis of three product categories: turbines and generators and transformers.

The study is presented in 3 parts: Part 1, comprises all aspects of the study leading to the pre-feasibility analyses. Part 2, is the pre-feasibility study on turbines and generators, and Part 3, is the pre-feasibility study on transformers[1/]. Other power equipment, namely: switchgear equipment and power boilers have also been selected for pre-feasibility analysis.

2. The data relating to the present status and future developments in networks and equipment were collected from electricity authorities. In general, the data were not elaborate especially on transmission and distribution lines as well as transformers. Nevertheless it became evident that most national networks were not fully integrated. Consequently, relatively small generating units of various sizes have been used, including diesel units.

1/ ECWA, Development of Selected Industrial Branches, 1985.

Another feature of present networks is the lack of unified standards for equipment and systems from one country to the other. This hindered the integration of the region's networks and even connections between neighbouring countries.

Regarding future developments, thermal generation, steam and to a lesser extent gas, will become predominant, transmission voltages will be higher in the future. These trends are indicated by the planned power programmes in the region, although admittedly the time span they cover is short.

The trend towards thermal generation was also obtained by surveying the region's potentional sources of energy which indicated that hydropotential was really limited, whereas thermal resources were abundant. Nuclear generation is not envisaged to be utilized in the region on a commercial scale in the foreseeable future, because of economic considerations.

In general, the size of future generating units will become larger, many units will be in the 300 MW range during the 1980s and 1990s.

3. The data used for projecting the growth of power equipment were collected from many sources - electricity authorities, regional and international organizations, and consulting firms operating in the region. Invariably the available forecasts covered short time periods and were inadequate. As a result, a great deal of judgement had to be applied for making the projections, especially in view of the fact that the projection period extends to the year 2000, a choice dictated by the long maturation period characteristic of heavy power equipment.

In this context, the projections tended to be conservative, keeping in mind the ultimate objective of evaluating the viability of local manufacturing, which would be more viable if actual demand turned out to be greater than the projected demand.

According to the projections, the average annual increase in the installed generation capacity for the whole ECWA region will be 2628 MW between 1981 - 1985, and 7,679 MW and between 1996 and the year 2000.

The corresponding growth of demand for turbines, generators and transformers was derived from these projections. The annual investment in this equipment was calculated and found to reach an average of US$ 373 million between 1981-1985, US$ 673 million between 1986-1990, US$ 714 million between 1991-1995, and US$ 1088 million between 1996 and the year 2000.

Finally, projections were made for the number of generating units within the sizes envisaged for the future, namely 100 MW, 150 MW, and 300 MW capacity for steam units and 50 MW and 100 MW capacity for gas units.

4. Turning to the supply side, the study indicates that the heavy power equipment (turbines, generators, power transformers) industry has the following characteristics:

(a) The equipment are invariably custom-designed according to specifications set by customers. Each customer has his own specifications which apart from parameters also take into account safety regulations applicable to his country;

(b) The product group or unit size form the basis for specialization by manufacturers, and by divisions (or plants) of larger firms;

(c) Large orders and long lead times demand large amounts of working capital. Production equipment and facilities require large capital investment. The trend towards larger equipment and the introduction of nuclear energy for the generation of electrical power have necessitated huge R & D expenditures - in certain cases 8 to 10 per cent of sales value;

(d) The large size of individual orders and their irregularity cause variations in the factory's workload and make programming of the overall production activity very critical and prompt major manufacturers to diversify;

(e) The manufacture of heavy power equipment requires a wide variety of materials as well as semi-finished and finished products from the chemical equipment, electronic equipment, metal products, and other industries. The major materials are copper and silicon steel. In the industrialized countries, manufacturers of power equipment normally procure major components (forgings and castings, etc.) from specialised manufacturers. The absence of feeding industries is one of the major problems facing power industries in developing countries. In the initial phases of production, the major components can be imported. Some international manufacturers develop designs especially applicable to industries in developing countries. Ultimately, those industries must depend on local capabilities;

(f) Because of the huge capital investment and high cost of R & D and the relatively limited number of customers (electricity authorities, large industrial enterprises, railways etc.), competition has become very keen and many mergers have taken place. Only a few large multinational manufacturers are presently on the international scene, with operations in developing as well as in industrialized countries.

5. As for developing countries, the major problems facing them in establishing power industries are:

(a) Development of local technical skills;

(b) Development of supporting industries which, at least initially exert a negative influence on the cost of production;

(c) Acquisition of technology, including new product designs and processes;

(d) Development of the organization which can implement projects of this scope.

As a result very few developing countries have been able to establish turbines and generator manufacture.

In the ECWA region the existing power equipment industry is very limited (mainly small distribution transformers manufacture in Egypt and Iraq), and undertaken on a national basis.

6. In contrast, the manufacture of power equipment is analysed in this study in the context of a regional industry which has the following advantages over national industries:

(a) Larger market which reduces the unit cost of production and enhances localization;

(b) More efficient utilization of resources (capital and skilled labour) in the region as a whole;

(c) Development of regional co-operation with resulting social and economic benefits to the people of the region.

On the other hand, a regional industry faces unique problems because it has to deal with many governments and cater to the needs of various electricity authorities.

Its success depends on many factors which include acquisition of know-how from industrialized countries, development of local skills and supporting industries, development of competent organization and management, and the proper selection of products. Therefore the industry must establish linkages with the electricity authorities, governmental agencies and sources of technology.

7. The criteria used in the study for the selection of products for the regional industry include:

(a) Size of the market: the ability of the regional market to absorb the output of a viable manufacturing plant;

(b) Status of technology: products whose technology is expected to become obsolete or outdated are discarded;

(c) The order of priority of selected products is determined by their relative value in the power system, their impact on other equipment in the system, their role in the transfer of technology to the region, and the resources required for producing them.

8. The manufacturing data used in the prefeasibility studies were provided by major manufacturers of power equipment whereas the data on local wages, cost of production, etc. were provided by leading consulting firms and construction companies in the ECWA region.

The pre-feasibility study on turbines and generators was based on two typical products (150 and 300 MW steam turbines and generators) which fall within the envisaged range of sizes mentioned earlier. The manufacture of steam turbines, gas turbines, and generators would be undertaken in the same factory. Because the manufacturing linkages between steam and gas turbines are quite strong, the additional investment for producing gas turbines in a steam turbine factory is relatively low. As for generators, their manufacture entails the utilization of major expensive machinery and specialized skills required for manufacturing turbines. Another advantage of the joint manufacturing is the utilization of common transportation and handling facilities in the factory.

On the other hand, manufacturing linkages between these rotating machines, and transformers, which are static machines, are insignificant and suggest separate factories. The same thing is true in regard to other power equipment (switchgear, boilers).

9. The viability of a factory having an annual production capacity of 3000 MW, which is less than 50 per cent of the projected average annual increase in generation capacity required by the region during the second half of the 1990s, has been analysed.

The maturation period is estimated to cover 13 years: a 4 year pre-production (construction) phase and a 9 year production phase. The length of those phases depends on the product mix and local conditions in the country hosting the factory. In turbine and generator factories, a great number of components are manufactured and assembled. Extensive testing is performed at various stages of the production process. More and more operations are becoming automated, utilizing computer-controlled machines and electronic test equipment. Still most production operations, such as welding blades on the rotor shaft, require human skills of the highest calibre.

10. In the manufacture of turbines, the rotor is the most complex part. For generators, machining the rotor, manufacturing properly insulated coil windings and assembling them in the stator are the major operations.

High quality materials (copper, silicon steel, etc.) are used in generators. In the initial years of production, the factory must import a higher share of finished components than it produces locally. The degree of localization may increase, ultimately, to 82 per cent for turbines 96 per cent for generators, and 100 per cent for associated thermal equipment (condensers, HP and IP heaters, etc.).

Components such as rotor forgings will continue to be purchased, which is a practice followed by many international manufacturers of heavy power equipment. The investments needed for manufacturing such components (for example in foundries and forging plants) are so high that it is often left to specialized suppliers (steel mills, etc.). The procurement of the components may be undertaken with the assistance of the collaborating manufacturer in which case it must be stipulated in contractual documents.

The production machinery and equipment are quite expensive and complex. The regional industry must accept only the machinery which conform to international standards in order to prevent possible future difficulties concerning acquisition of spare parts or replacement of retired equipment.

It should be mentioned in this context that the machinery required for producing 300 MW units are capable of producing larger unit sizes; the threshold is about 500 MW. Moreover, the same machinery can produce industrial turbines and generators as well as a variety of motors.

11. The required work force is mostly highly skilled. Such skills are non-existent in the region. The development of a skilled work force is one of the most important conditions for the success of the regional industry. The training function must be initiated with the help of the collaborating manufacturer and must start at the beginning of the pre-production phase. It will continue indefinitely, though gradually becoming less intensive. The high cost of training will exert a negative influence on the profitability of the industry in the short run. In the long run, it will prove to be a very worthwhile investment.

12. The manufacture of turbines and generators can be done only with the assistance of a reputable international manufacturer. The scope of the required technology, and the form of collaboration (licensing, joint venture, etc.) can only be precisely defined in the project feasibility study. In general, the scope of technology can include:

(a) Technical know-how for the product mix, including specification of the product, technical software, etc.;

(b) Continuous flow of new R&D results;

(c) Know-how relating to production, installation, and after-sales servicing of the products;

(d) Dimensioning of production facilities, and specifications of machine tools, equipment, materials, and components;

(e) Documentation of the production processes and production control systems;

(f) Operational procedures and systems relating to inventory, incoming inspection, testing, and quality control;

(g) Training;

(h) Marketing and sales;

(i) Establishment, ultimately, of a local R & D capability;

13. The financial aspects of manufacturing turbines and generators were analyzed for two groups of countries roughly categorized according to wage level and construction cost. Group 1 includes the oil exporting countries, and Group II consists of the non-oil exporting countries.

The analysis shows:

		Group I	Group II
1.	Total fixed capital, all equity basis (million US $)	331	307
2.	Working capital, assumed short borrowing (million US $)	67	66
3.	Number of persons employed	1211	1211
4.	Payback period (years)	10	9
5.	Average undiscounted rate of return over 15 year-period on total cash (per cent per annum)	9	12
6.	Internal rate of return (per cent)	6	8
7.	Unit cost of production (US $ per MW)	78	76

14. The results and conclusions of the study can be summarized as follows:

(a) The manufacture of turbines and generators is economically viable but demands huge investment, entails long payback period, and offers moderate internal rate of return;

(b) Based on the results obtained in this study, which must be substantiated in a detailed feasibility study, it seems that the plant capacity should be higher than the 3000 MW assumed earlier;

(c) The location of the factory does not significantly influence the cost of production. This is attributed to the high share of material cost in the total cost of production;

(d) Although the factory is dimensioned for manufacturing electric power turbines and generators, other types of turbines and generators (industrial marines, etc.) as well as large size motors can be manufactured in the same factory. Such arrangements may smooth the work load peaking traditionally experienced in heavy power equipment factories;

(e) The execution of this project needs extensive preparations relating, among other things, to the following:

- Standardization of unit sizes and product specifications;

- Development of necessary technological infrastructure, including supporting industries;

- Development of an organization capable of implementing projects of this scope;

- Collaboration with international manufacturers;

- Selection of the manufacturing site; the factory must be accessible by highways or railroad and located near sources of electrical power and water;

(f) In the initial years of production, the factory should not produce unit sizes larger than 100 MW. The experience so gained will be put to use for manufacturing larger and more complex sizes later, i.e., the 150 MW and 300 MW units.

ANNEX 5

LIST OF PARTICIPANTS

H.E. Abdul Tawab Mulla Howaish	Senior Under-Secretary Ministry of Industry Baghdad, Iraq.
Mr. V. Krishnamurthy	Chairman Maruti UDYOC New Delhi, India.
Mr. A.R. Ismail	Station Manager Jordan Electricity Authority Zerka, Jordan
Mr. Federico Mas	Manager Industrial Development NAFINSA - Mexico.
Mr. M.A. Gabr	Arab Industrial Investment Co. Baghdad, Iraq.
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Mr. K. Baltensperger	Vice-Director BBC Brown, Boveri & Company Ltd. Baden, Switzerland.
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Mr. A. Lansink	Third Secretary (Commercial) Royal Netherlands Embassy Baghdad, Iraq.
Mr. Ghazi M. Kamel	Chief Engineers State Electricity Organization Baghdad, Iraq.
Mr. W.S. Mahmoud	General Manager Generation and Transmission of Electric Power Baghdad, Iraq.
Mr. L.N. Al-Saadi	Director General State Electricity Organization Baghdad, Iraq.
Mr. Ibrahim Haba	Chief Engineer Major Electrical Projects Baghdad, Iraq.
Mr. S.B. Ishak	Expert Arab Industrial Development Organization (AIDO) Baghdad, Iraq.
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Process Flow Diagrammes

and Quality Control

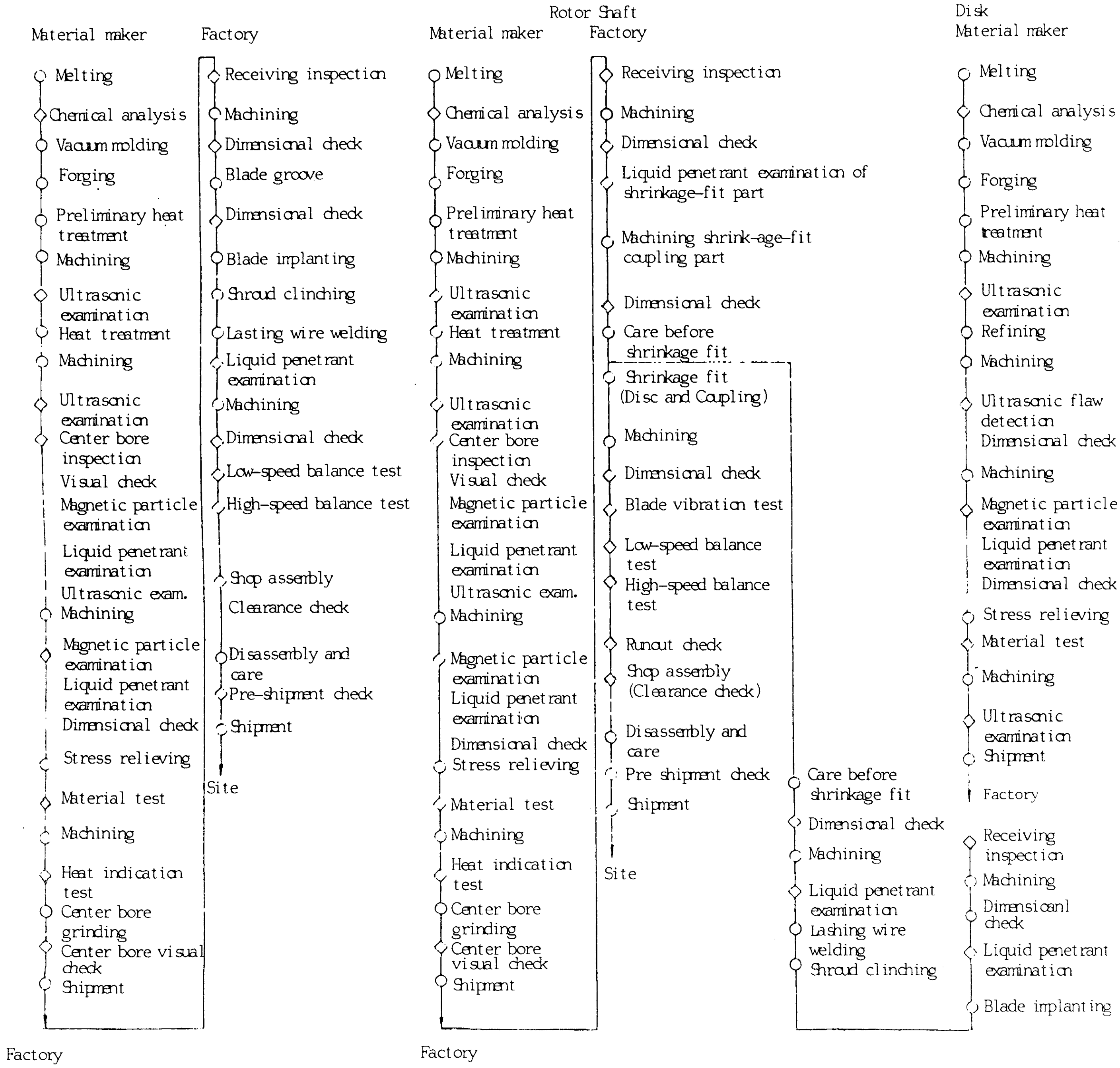
1. Turbine Rotors

Great care is exercised for securing the reliability of the turbine rotor as the most important part throughout the design, production and inspection stages. Rotor quality has markedly improved in recent years thanks to the progress of rotor production technology and non-destructive examination.

A strict check or test point is provided in each stage of the process from the acceptance of the material in the factory to the shipment of finished rotor from the factory to assure perfect quality control. In addition to the checks at the turbine factory rotors are directly checked by MHI (Mitsubishi Heavy Industries) inspectors at the material makers'.

Production Flow Chart for Solid Type Turbine Rotor

Production Flow Chart for Shrinkage Disc Type Rotor



Appendix

Sheet 2

2. Blades

The blades constitute the heart of the turbine. During their manufacture, therefore, the blades are strictly checked for performance and strength to assure quality.

Performance:

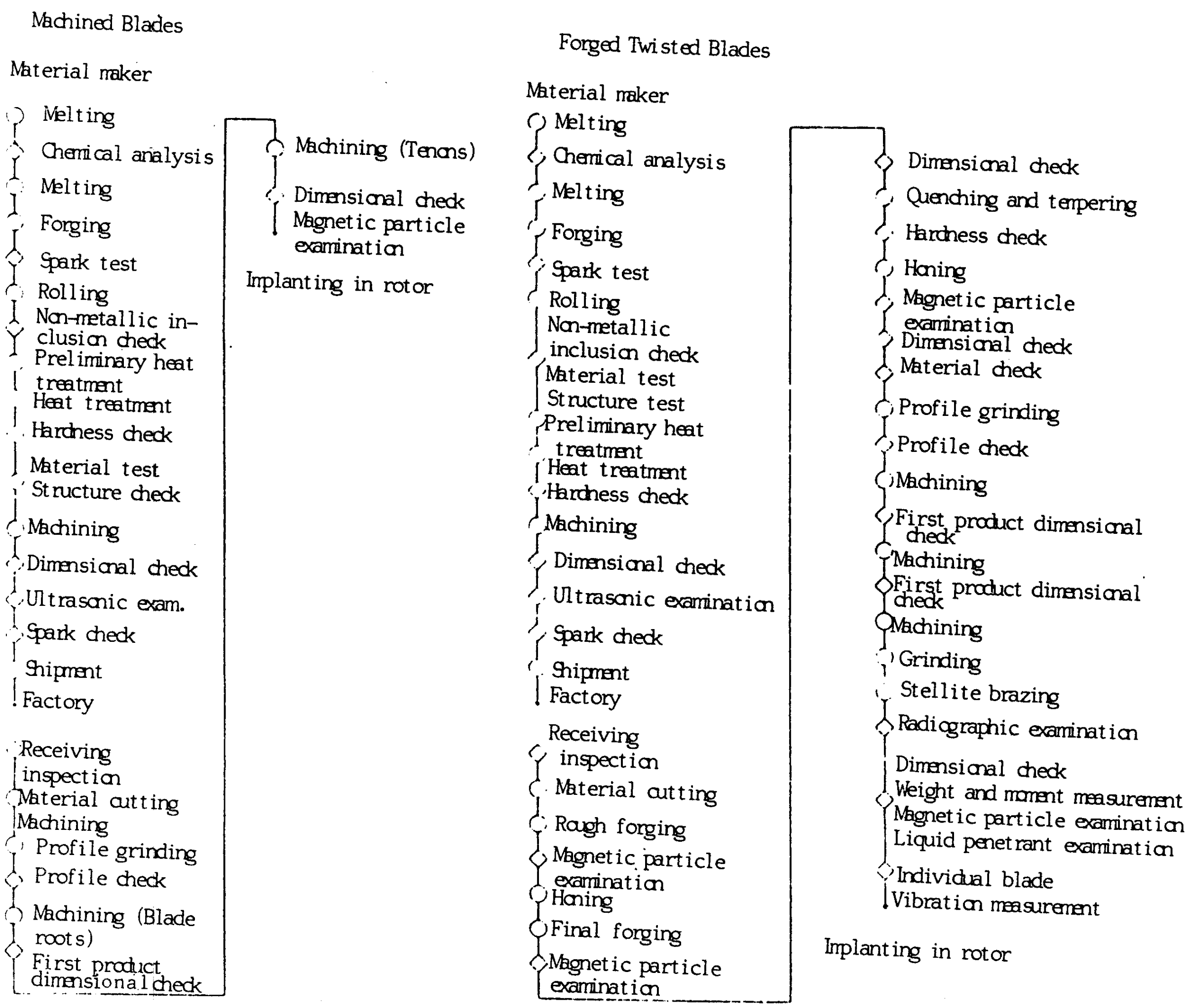
Machined blades are sampled, and put to a profile check and a throat measurement check by using gauges.

All the forged twisted blades are put to a profile check by which their typical cross sections at several points are checked with gauges. After implanting them in the rotor, the forged twisted blades are checked for throat measurements.

Strength:

the material which has been verified to meet the material requirements by the material maker through ultrasonic examination and magnetic particle examination methods and various confirmation tests is accepted and processed. Machined blades are put to a dimensional check along; with magnetic particle examination and liquid penetrant examination, forged twisted blades are checked for the soundness of the material by magnetic particle examination and then a material test after heat treatment. After stellite brazing, a radiographic examination is conducted to check how stellite has been brazed. Forged twisted blades are individually checked for vibration to assure quality, and those blades which require natural vibration control are put to a group blade vibration measurements after implanting in the rotor.

Turbine Blade Production Flow Chart



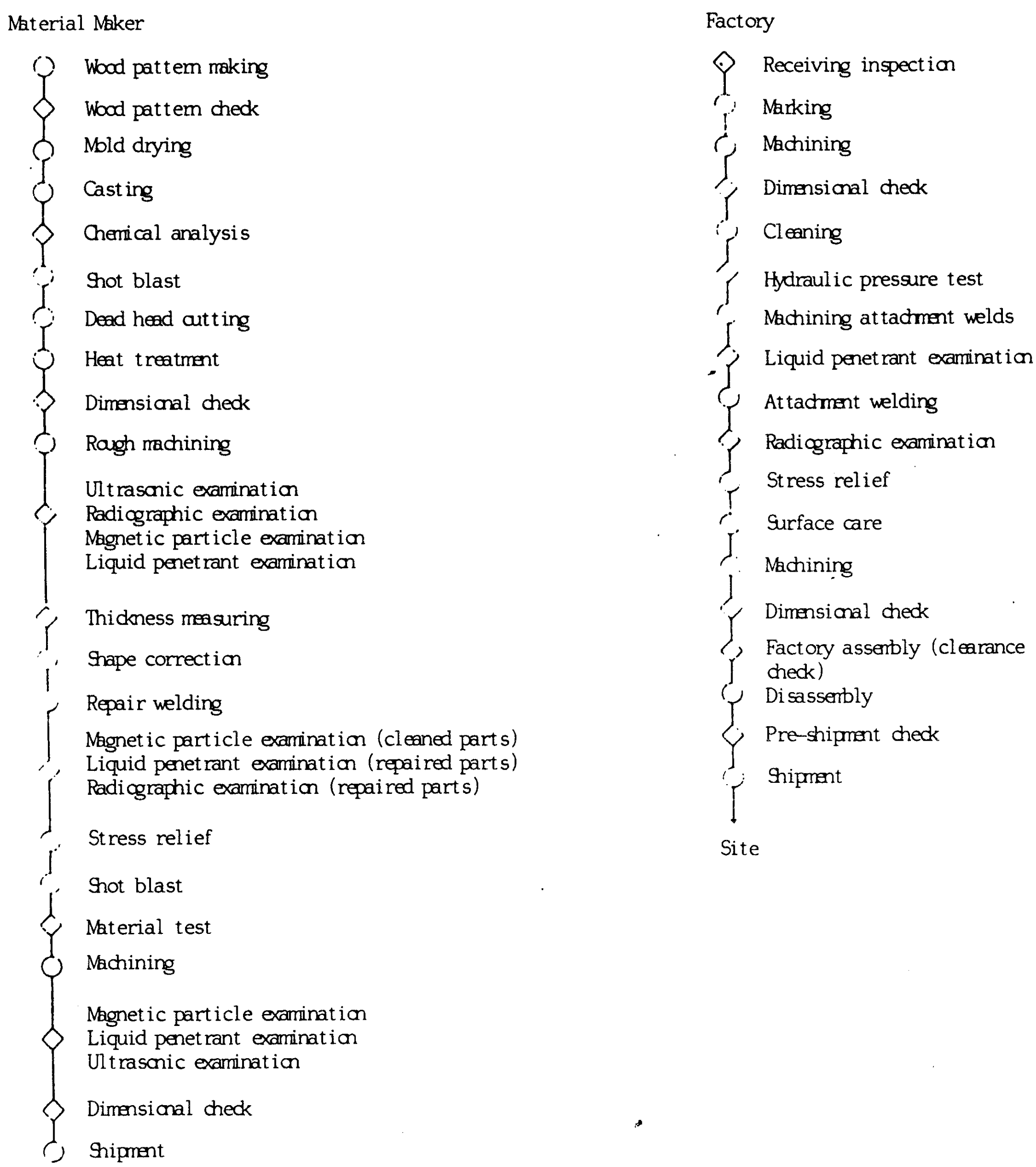
Source: Mitsubishi, Japan.

3. Casings

Large-sized cast casings are manufactured from the material purchased after it has passed strict tests and checks. Due to the improvement of manufacturing and inspection techniques, repairs are hardly necessary these days. Large-sized welded steel plate casings are manufactured by special steel plate welding under exacting welding control to improve product reliability.

Numerical control (NC) horizontal boring machines are mainly used for machining the casings; to assure sufficient accuracy.

Cast Casing Production Flow Chart



Source: Mitsubishi, Japan.

4. Governors, Main Steam Valves, and Safety Devices

The governors main steam valves and safety devices require a very high degree of reliability to control stability during operation, quick response in case of system failure, or positive operation to shut off the steam in emergencies.

In manufacturing these control devices, tests and checks are conducted by taking control performance and functions into consideration to assure their reliability.

The main steam valves are put to not only mechanical tests but various kinds of non destructive examination to guarantee quality.

(1) HYDRAULIC GOVERNOR

Production Flow Chart for Control and Safety Devices

- Arrangements for purchase of materials and finished parts
- Receiving inspection
  Material test
  Chemical analysis
  Dimensional check
  Characteristics test (springs)
  Function test (finished parts)
- Machining
- Dimensionl check
- Liquid penetrant examination
- Heat treatment (Hardening, nitriding)
- Hardness check
- Final finishing
- Checking finished parts
  Dimensional check
  Surface roughness
  Appearance check
- Partial assembly
- Clearance check, alignment adjustment and check
- Overall assembly
- Individual tests static characteristic test
- Combined tests Open loop
  Dynamic characteristic test
  Static characteristic test
- Shipment

To site

Production Flow Chart for Main Steam Valves and Servo Motors

- Arrangements for purchase of materials and finished parts
- Receiving inspection
  Material test
  Chemical analysis
  Dimensional check
  Non destructive examination
  Characteristic test (springs)
- Rough machining
- Dimensional check
  Liquid penetrant examination
- Welding
- Dimensional check
  Liquid penetrant examination
- Stress relief annealing
- Liquid penetrant testing
- Machining
- Dimensional check
  Liquid penetrant examination
- Pressure test
- Heat treatment
- Hardness check
- Final finishing
- Checking finished parts
  Dimensional check
  Surface roughness
- Parts assembly
- Checking finished parts
  Dimensional check
  Surface roughness
- Overall assembly
- Individual tests
  Static characteristic adjustment
  Functional test
- Shipment

To site

Source: Mitsubishi, Japan.

(2) Electro-Hydraulic Governors

Production Flow Chart for Electrical Parts

- Purchase arrangements, design examination
- Receiving inspection
  High-temperature exposure test
  Temperature cycle test
  Normal temperature parameter test
  Electrical performance test
- Printed circuit card
- Card check
  High-temperature continuous continuity test
  High-temperature performance test
  Heat aging test with power switched off
- Card frame test
  Temperature cycle test with power switched on
  Normal-temperature card combined test
- EH governor panel
  Instrument wiring
- Checks
  Structural dimension check
  Wiring check
  Screw tightness check
- Electrical characteristic tests
  Connection check
  Withstand voltage test
  Test on characteristics of each circuit
- Governor function test
  Normal temperature combined test
- Characteristic tests
  Temperature cycle test with power switched on
  Normal temperature continuous continuity test
  Noise test
  Vibration impact test
- Shipment

Production Flow Chart for Hydraulic Devices

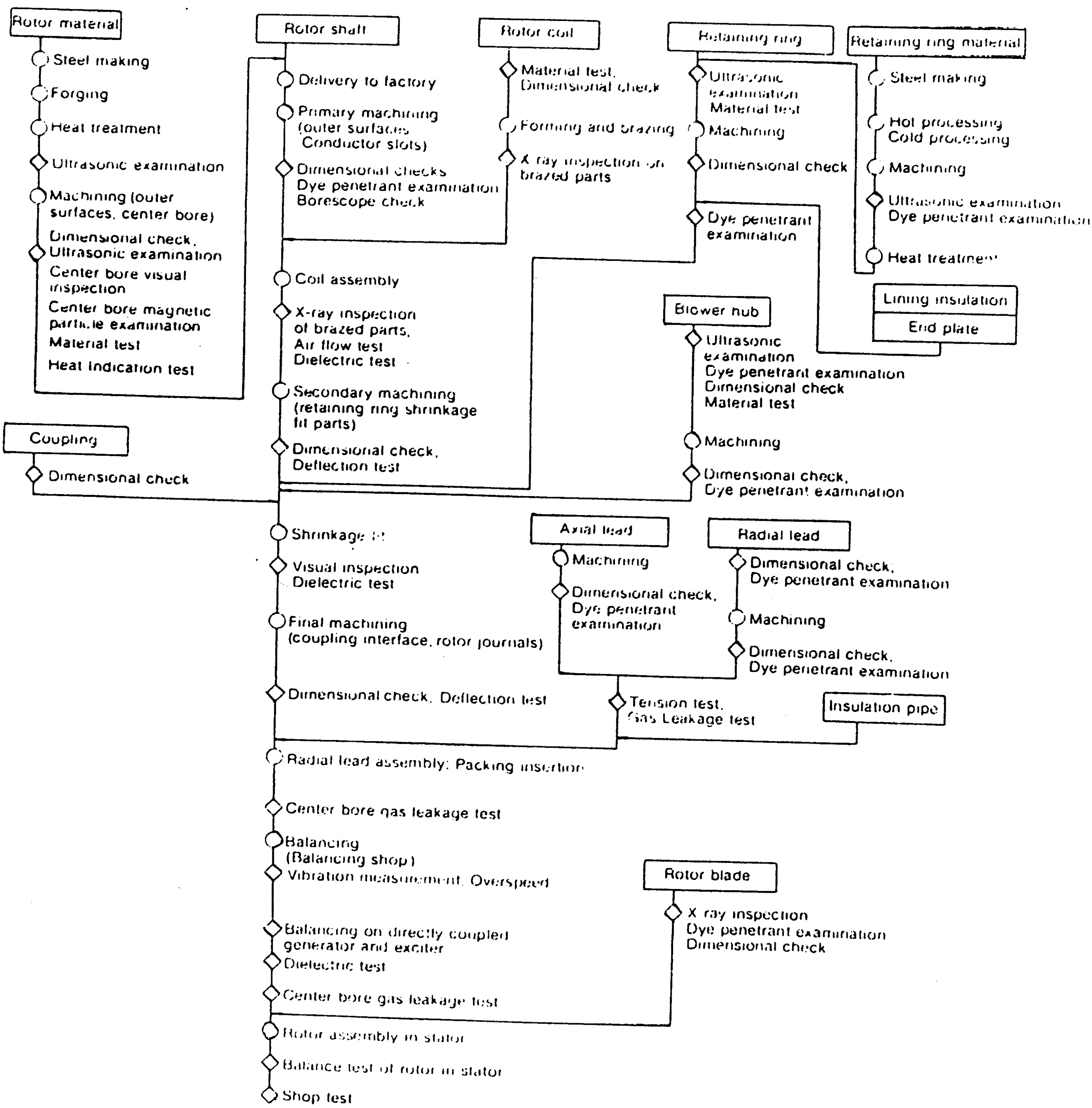
- Purchase arrangements
- Receiving inspection
  Chemical test
  Physical test
  Non-destructive test
- Rough machining
- Check
- Welding
  Heat treatment
- Check Dimensional check
- Forming
- Intermediate check
- Surface treatment
- Check
  Hardness
  Plating thickness
- Finished parts check
- Parts Assembly
- Check
- Overall assembly
- Function tests
  Appearance check
  Performance check
  Pressure check
  Function test
  Operation test
- Shipment

Source: Mitsubishi, Japan

6. Generator Rotors

Generator rotors are manufactured by the following processes from the materials. Strict inspections are performed at each process of rotor manufacturing to assure complete quality control.

Generator Rotor Production Flow Chart

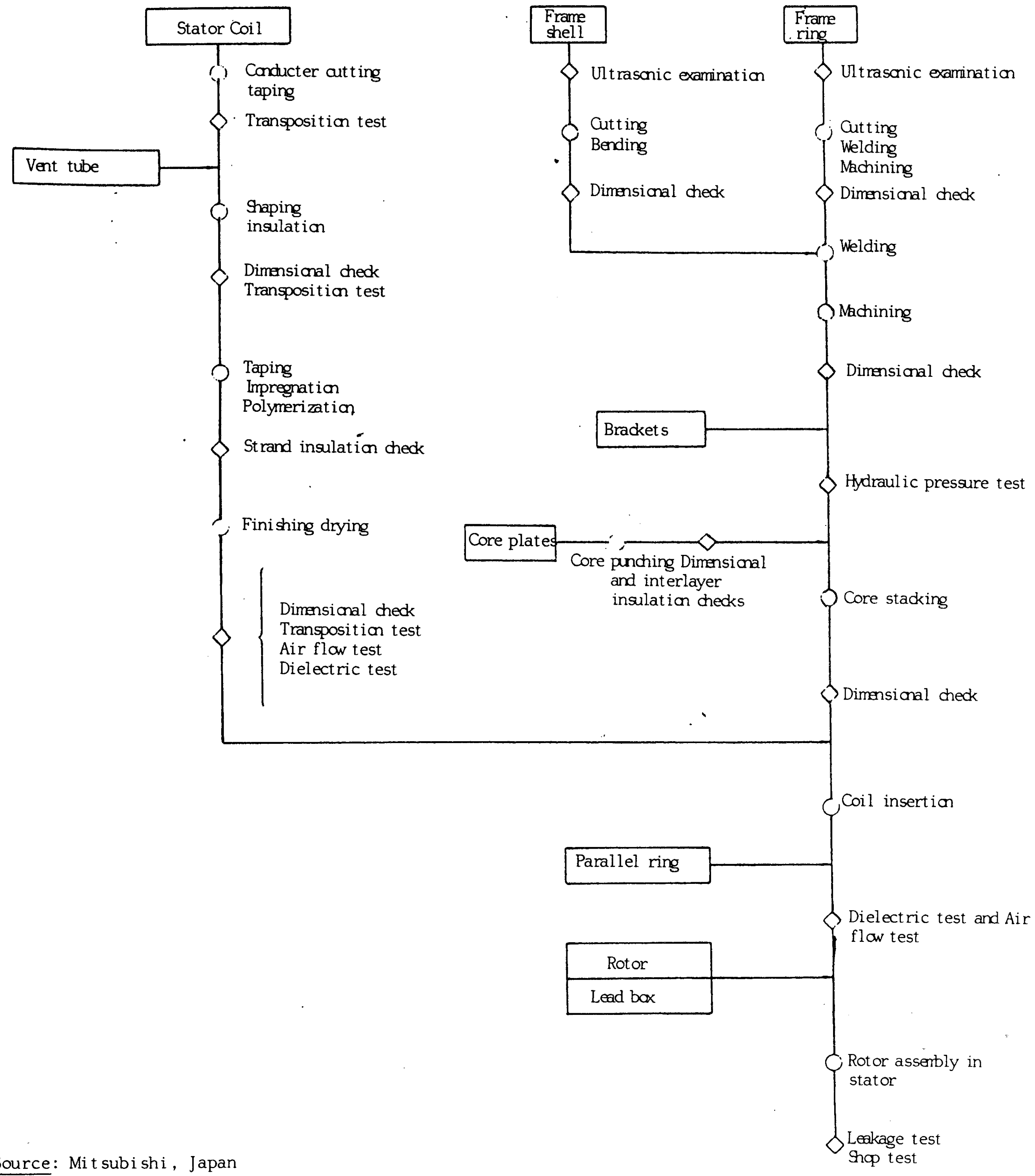


Source: Mitsubishi, Japan.

7. Generator Stators

Generator stators are manufactured under strict quality control as the following flow chart shows.

Production Flow Chart for Generator Stators



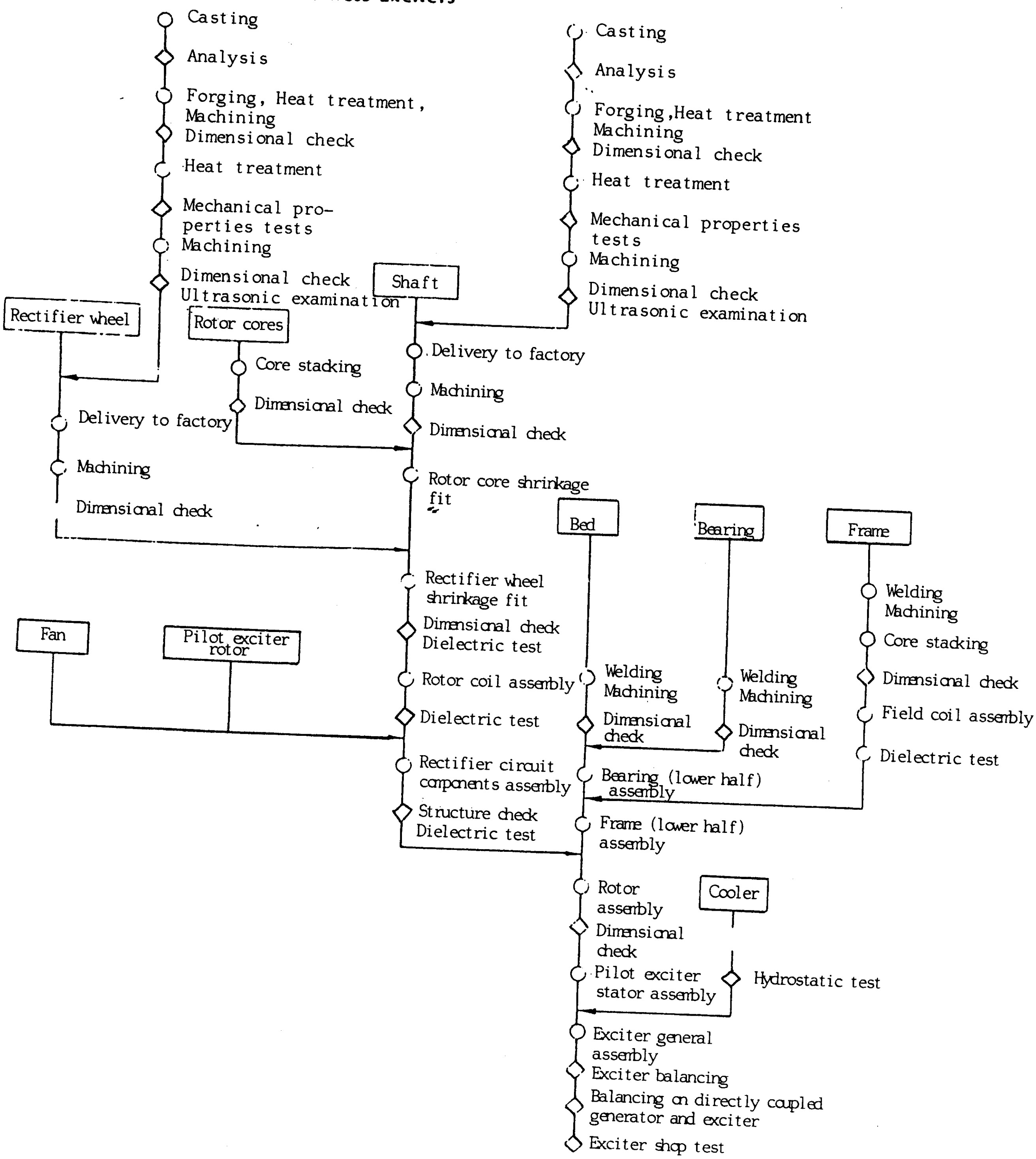
Source: Mitsubishi, Japan

Appendix
Sheet 8

8. Brushless Exciters

Brushless exciters are manufactured under strict quality control as the following flow chart shows

Production Flow Chart for Brushless Exciters



Source: Mitsubishi, Japan

DEVELOPMENT OF SELECTED INDUSTRIAL BRANCHES NO.1

STUDIES ON REGIONAL CO-OPERATION IN THE DEVELOPMENT OF CAPITAL GOODS AND HEAVY ENGINEERING INDUSTRIES

UNITED NATIONS
ECONOMIC COMMISSION FOR WESTERN ASIA

THE VIABILITY OF ESTABLISHING A REGIONAL ELECTRIC POWER EQUIPMENT INDUSTRY IN THE ECWA REGION

VOLUME II

ABBREVIATIONS

A/D	Analogue to digital
ARABSAT	Arab League Countries' Satellite
b/s	Bits per second
CKM	Circuit or pair kilometres
D/A	Digital to analogue
dB	Decibel
DEL	Direct exchange lines
DSD	Direct subscriber dialling
ECWA	Economic Commission for Western Asia
FDM	Frequency division multiplex
H.F.	High frequency
Hz	Hertz
IBRD	International Bank for Reconstruction and Development
IC	Integrated circuit
ITU	International Telecommunication Union
Kg/cm^2	Kilogramme/square centimetre
m	Metre
m^2	Square metre
m^3	Cubic metre
MTBF	Mean time between failures
MWh	Megawatt hour
O&M	Operation and maintenance
OES	Order execution and service
OJT	On-the-job training
OMC	Operation and maintenance centre
PABX	Private automatic branch exchange
PAX	Private automatic exchange
PBX	Private branch exchange
PCB	Printed circuit board
PCM	Pulse code multiplex
PE	Ployethylene
PGS	Project generation system
PVC	Polyvinyl chloride
RAM	Random-access memory
R&D	Research and development
REPROM	Reprogrammable memories
SKM	Standard kilometres of cables; one kilometre of a cable having 100 pairs or circuits
SPC	Stored programme - control system
TC	Training centre
TEO	Technical efficiency and organization
TV	Television
V	Volt
VDU	Visual display unit
VF	Voice frequency

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VOLUME II

PART 1

BASIC ECONOMIC AND TECHNOLOGICAL CONSIDERATIONS

INTRODUCTION

Objective of the study

In line with the terms of reference established by the Joint ECWA/UNIDO Industry Division concerning the development of regional engineering industries in the ECWA region, the objective of this study is to evaluate the viability of establishing a regional industry for manufacturing electric power equipment.

Rationale

The selection of electric power equipment for this study was based on the following factors:

(1) The great increase of demand for power equipment anticipated in the region, based on future power programmes and national development plans. Power systems represent a very important part of the infrastructure necessary for development of the industrial and other sectors of the economy.

(2) The expectation, based on preliminary assessment of the region's markets, and examination of manufacturing requirements (huge investments, high and diversified skills) that heavy power equipment lends itself to local manufacture only at the regional level.

(3) The significant contribution in the transfer of expertise and skills to the region which is expected from the high-technology power equipment industry, especially heavy equipment.

(4) The expected role of the regional power equipment industry in stimulating the development of related industries. Foremost among these are the supporting industries which supply the materials, semi-finished parts, and finished products required for manufacturing power equipment. Those industries include:

(i) Foundries and forging plants: forged rotors, castings, etc.

(ii) Metal products industry: copper and steel products, etc.

(iii) Chemical equipment industry: boilers, chemical process equipment, etc.

(iv) Electronic industry: instrumentation and communication products, etc.

The development of the supporting industries stimulates, in turn, the development of other industries which also utilize their products; for example, the development of steel mills stimulates the development of the heavy mining equipment industry.

Scope of the study

The major aspects of the study are to:

(1) Examine the present status of the region's power systems and the planned (or expected)1/ development of those systems, in order to determine future strends relating to such important issues as types of generation and unit sizes;

(2) Project the growth of the region's power systems, and thereby the growth of specific product groups;

(3) Examine the characteristics of the power equipment industry which, coupled with an evaluation of existing power equipment industries in the region, makes it possible to identify the technological infrastructure which will have to be developed;

(4) Describe the envisaged regional industry and the links which it must develop with governments, electricity authorities, and international manufacturers of power equipment;

(5) Develop criteria for selecting candidate products for the regional industry and subsequently, for pre-feasibility analysis;

(6) Analyse at the pre-feasibility level the selected products (turbines, generators and transformers) to make a preliminary assessment of the requirements entailed (materials, production equipment and facilities, personnel, technology, etc.) and the economic implications (size of investment, rate of return, pay-back period, etc.)

It should be emphasized at this point that the results obtained from the pre-feasibility studies are broadly indicative, and must be substantiated by detailed feasibility studies where many parameters, which are not well-defined at this stage, could be completely specified, e.g. location of the factory, precise specifications of the product, product mix, plant capacity, etc.

Sources of information

The manufacturing data, including costs of materials and production equipment, were supplied by BBC Brown Boveri and Co. of Switzerland. General Electric, USA, also provided important information for this study. The data on local wages and construction costs were supplied by leading consulting firms and consulting companies in the region.

1/ "Expected" refers to developments which have not been formally planned, yet are expected by the authorities concerned to be included in later plans.

The data used for projecting the growth of power equipment came from many sources: electricity authorities, the Arab Fund for Economic and Social Development (AFESD), the International Bank for Reconstruction and Development (IBRD), and power consulting firms operating in the region. The collected data had a number of major weaknesses:

(1) The information relating to present status and future development of power systems, especially the networks (transmission and distribution lines, transformers) was inadequate;

(2) Substantial differences were noted between forecasts made at different times, even within one year, or by different forecasters (for example, electricity authorities, consultants);

(3) The basis upon which the forecasts were made was not stated;

(4) The projection periods covered by most forecasts were very short.

VOLUME II

CHAPTER 1

ELECTRIC POWER SYSTEMS AND EQUIPMENT

1.1 General

The information presented in this chapter forms the background for subsequent discussions on the demand and manufacturing aspects of power equipment. It includes the following topics:

(a) A description of the power system and its equipment;
(b) The present status of power systems in the ECWA region;
(c) Future power systems in the region.

1.2 Description of the power system

The function of the power system is to generate electrical power and to transmit it to the users, such as households and factories. The power generated at the users, such as households and factories. The power generated at the power-generating plant is transmitted to the loads via a network (grid) of transmission lines, distribution lines, and transformer stations.

At the generating plant, different sources of energy (hydro, thermal, nuclear) can be used to drive a prime-moving machine, the turbine, which in turn drives a generator. Through this process the different types of energy are transformed into electrical energy.

The selection of the best type of generation is based on economic and practical considerations, among which are the cost of equipment, availability of sources of energy, e.g. hydropower, natural gas, process gas, distillates, crude oil, residual oil, uranium and their relative cost.

Each type of generation requires different equipment; for example, boilers are used only in steam plants, while turbine blades are designed differently for hydroelectric, steam, and gas turbines: gas-turbine blades, which are exposed to hot gases, are made of special oxidation resistant materials.

Based on economic considerations such as the cost of fuel, a combined cycle (gas and steam) generation system may be used in thermal plants. The gas turbine is driven, as usual, by the expanding hot gases coming from the combustion chambers where the injected fuel and compressed air are burned. The hot gases, instead of being allowed to be exhausted to the atmosphere, are recovered and used to heat a boiler to produce steam which drives the steam turbines.

Power plants normally utilize different generating units for base and peak loads. In general, hydropower, steam and nuclear generating units are used for the large base loads, and gas units for peak loads.[1] The generation capacity installed in the plant, or in the entire power system if it is integrated, must be able to accommodate the maximum expected load demand.

At the generating plant, the output of the generator is connected to be a step-up transformer (or transformer bank) for stepping up the voltage and proportionately stepping down the current of the generated power before it is transmitted. In this way, larger amounts of power can be transmitted more efficiently (less line losses)[2]. Thus, higher and higher transmission line voltages are being used in power systems.

Since transmission and distribution lines have reactive elements,[3] the phase angle between the voltage and current of the transmitted power may increase to the point where instability occurs, especially if the line is very long. This problem is solved by inserting phase correction networks at various points in the line, or by stepping-down the line voltage.

The high transmission voltages, which may exceed 700 kV, are eventually stepped down to very low values (as low as 220V) before the transmitted power reached its users. This is done, in stages, by means of step-down transformers and distribution lines.

By the time the generated power reached its users, a significant portion of it is lost. Even in what is regarded as an efficient system, as much as 6 to 10 per cent of the generated power is lost. Losses occur in all parts of the power system: the generating plant (auxiliary equipment and step-up transformers), transmission lines, distribution lines, and step-down transformers. To minimize losses, manufacturers of power equipment are constantly striving to develop better materials for transformers, cables, wires, and other equipment.

The power system encompasses a huge amount of equipment. A list of the main power equipment is given in the annex at the end of this part.

1.3 <u>Present status of power systems in the region</u>

(a) Most national networks are not fully integrated, that is, not all loads and generating plants are connected to one network. This is based on the following observations:

(i) Generating plants which serve specific regions or communities; "captive plants" in factories and other enterprises, with the following disadvantages:

1/ These are caused by periodical increases in consumed power, e.g., during early evening hours, certain summer months etc.

2/ Mainly I^2R losses.

3/ Inductance and capacitance.

- Higher costs because individual plants have reserve capacities to meet peak loads. The combined installed capacity of the plants is much greater that it would be if they were connected to one national network;

- Interruption of service is more likely to occur because a failure in one plant means interruption of service to its load. No interruptions would occur if the load were connected to a national network because it would be served by other generating plants;

- The use of generating units of various sizes because isolated loads vary in size. Table 1.1 lists the units sizes used in the region as extracted from the data available to this study. If the networks were integrated, then the total load would be served by a minimum number of unit sizes. Such an arrangement has operational as well as manufacturing advantages;

- The inability of the power system to use larger generating unit sizes which are more economical because of their lower initial and operating costs;

- The use of various transformer sizes and associated equipment in the generating plants to accommodate the wide range of generated power.

(ii) Isolated transmission and distribution lines to serve isolated load centres; an extreme example of this situation is found in the Yemen Arab Republic. The resulting disadvantages are:

- The use of a wide range of line voltages which necessitates the use of an assortment of transformer sizes, switch gear, and control equipment. This is illustrated in table 1.2 which lists the line voltages used in the region as extracted from the data available to this study;

- The inability of the power systems to use higher transmission voltages which are more efficient and economical, or to standardize transmission voltages which facilitate interconnections between national networks.

(b) Some countries adopt different electrical standards. Although most countries adopt European standards (220 V and 50 Hz), Saudi Arabia adopts American standards (117 V and 60 Hz) while Lebanon adopts both (220 V and 117 V). This situation further impedes standardization of equipment.

Table 1.1. Existing generating plants in ECWA region (capacity in MW)

Type of generation	Bahrain 1977	Egypt 1975	Iraq 1977	Jordan 1977	Kuwait 1976	Lebanon 1973	Oman 1976
Hydro	none	2 x 11.5 7 x 46 12 x 175	3 x 28 1 x 100	none	none	3 x 0.34 3 x 0.7 2 x 0.8 3 x 1 3 x 1.6 a/	none
Steam	4 x 30	2 x 10 3 x 12.5 5 x 15 4 x 16 1 x 20 2 x 26.5 10 x 30 4 x 60 3 x 65 3 x 87	2 x 2.5 1 x 5 1 x 6 3 x 12.5 7 x 15 4 x 20 4 x 40 2 x 67.5 2 x 100	2 x 33 ... x 66 ... x 100	4 x 7.5 4 x 10 3 x 30 5 x 70 6 x 134 1 x 150	3 x 5.7 1 x 15 1 x 30 2 x 32 2 x 65	3 x 9.37
Gas	5 x 3 3 x 5 6 x 6 3 x 13 1 x 14 16 x 15 2 x 20 2 x 22 5 x 25	2 x 14 1 x 17 3 x 20	15 x 20 1 x 27.5 3 x 63.3	1 x 15 1 x 20	2 x 25 3 x 40.8	none	none
Diesel	unknown	unknown	unknown	52 x 0.05 39 x 0.1 53 x 0.25 18 x 0.5 33 x 1 6 x 3 4 x 6	unknown	number and sizes unknown but totalling 3.5 MW	number and sizes unknown but totalling 71.3 MW
Nuclear	none	none	none	none	none	none	none

a/ Also 3 x 1.8, 2 x 1.9, 3 x 2.5, 3 x 2.8, 3 x 4.2, 3 x 4.3, 3 x 4.5, 3 x 5.7, 2 x 7.5
2 x 8.5, 2 x 36

Table 1.1 (Continued)

Type of generation	P D R Y 1977	Qatar 1976	Saudi Arabia	Syria 1977	U A E 1978	Y A R 1977	ECWA region most popular sizes
Hydro	none	none	none	2 x 3.5 2 x 4 7 x 100	none	none	175 MW 100 MW 46 MW
Steam	3 x 4	4 x 15	unknown	1 x 5.7 2 x 6.25 1 x 13.75 4 x 15 3 x 30	1 x 15 4 x 20 5 x 30	none	30 MW 15 MW 20 MW
Gas	2 x 6	2 x 15 4 x 17.5 2 x 25 2 x 40 4 x 44 6 x 56	unknown	14 x 20	2 x 2 3 x 3.3 5 x 13.5 12 x 17 2 x 17.5 4 x 18 8 x 18.5 2 x 20 2 x 25 2 x 61	none	20 MW 15 MW 25 MW
Diesel	6 x 0.06 2 x 0.1 2 x 0.12 3 x 0.9 3 x 2.75 5 x 5	1 x 0.12 4 x 0.19 5 x 0.32 4 x 0.39 2 x 0.5 6 x 0.54 2 x 2.5 5 x 2.6	unknown	number and sizes unknown but totalling 14 MW	10 x 0.3 15 x 0.38 11 x 0.86 6 x 1.5 8 x 1.75 12 x 1.9 11 x 2 14 x 3.4 6 x 3.5 7 x 5 13 x 7 7 x 11.5 2 x 17	number and sizes unknown but totalling 17.6 MW	0.25 MW 0.05 MW 0.1 MW 0.5 MW 5 MW
Nuclear	none	none	none	none	none	none	none

Source : Joint ECWA/UNIDO Industry Division

Table 1.2. Existing transmission and distribution lines in ECWA Region (Voltage and length)

	Bahrain 1975		Egypt 1977		Iraq 1973		Jordan 1977		Kuwait 1975	
Distribution lines	230/400V 11 kV	102km n.a.	220/380V 3 - 6 kV 11 kV	n.a. n.a. 13 000km	220/380V 11 kV	n.a. n.a.	230/400V 6.6-11 kV	2312km 470 km	220/415V 6.6-11 kV	5075km 2150km
Transmission lines	33 kV 66 kV	97km 34 km	33 kV 66 kV 132 kV 220 kV 500 kV	1 600km 2 600km 3 550km 2 400km 838km	33 kV 66 kV 132 kV	n.a. n.a. 2 700km	33-66 kV 132 kV	586 km 45 km	33 kV 132 kV	805km 430km

	Lebanon 1973		Oman		P D R Y 1976		Qatar 1976		Saudi Arabia 1980	
Distribution lines	110/220V 11-20 kV	5 000km 2 000km	n.a.	n.a.	240/420V 11 kV	674km 199km	n.a. 11 kV	n.a. 546km	117-200V 13 kV	n.a. n.a.
Transmission lines	33 kV 66 kV 150kV	n.a. 526km 55km	n.a.	n.a.	33 kV	92km	66 kV 132 kV	186km 15 km	n.a.	3 540km

	Syria 1975		U A E 1977		Y A R 1977	
Distribution lines	127-220V 20 kV	n.a. 3 070km	n.a. 11 kV	n.a. 121km	230/420V 6.3 kV 10 kV	n.a. n.a. n.a.
Transmission lines	66 kV 230 kV	1 068km 1 094km	33 kV 400 kV	65km 87km	n.a.	n.a.

Source: Joint ECWA/UNIDO Industry Division.

(c) Little progress has been made towards developing an integrated regional network or even sub-regional networks. So far, interconnections1/ have been made between Lebanon and Syria, and between Syria and Jordan. The advantages of such interconnections include:

(i) Utilization of different peaking times to transmit power from one country to another. Thus, there would be no need for every country to install the generation capacity dictated by its peak load;

(ii) The ability of a country experiencing a network failure to receive power from another country;

(iii) The ability of some countries without sources of energy to buy electrical power from other countries at a lower cost than if they had to generate it.

(d) The types of generation used in the region are hydroelectric, steam, gas, and diesel. The sidespread use of diesel generation reflects the extensive use of small generating units.

1.4 Future power systems in the region

A. Types of generation: An attempt is made here to project the types of generation which will prevail in the region. Only those types which are used commercially are examined; they are hydroelectric, steam, gas, diesel, and nuclear.

A survey of existing and potential sources of energy in the region indicates the following:

(a) Only five countries (Jordan, Egypt, Iraq, Lebanon and Syria) have any hydro-power potential. Jordan's potential is very limited, amounting to about 55 MW at the Zarqa and Yarmouk Rivers. Egypt has already utilized two-thirds of its potential by having a combined installed capacity of 2,445 MW at the Aswan Dam and the Aswan High Dam. Technically speaking, an additional 1,000 MW can be developed by using the 70-metre head between Aswan and Cairo, and by utilizing the Qattara depression. However, the economic viability of those schemes has not yet been established. Iraq's hydropower potential amounts to about 3,000 MW distributed among the following dams: Mosul (500 MW), Bekhme (600 MW), Haditha (550 MW), Dokan (400 MW), Derbendikhan (300 MW), Hamrin (50 MW), and Tharthar (600 MW). However, by 1990, all that potential will have been harnessed except at Hamrin, Tharthar, and possibly Derbendikhan which together total about 950 MW. Lebanon's hydropower potential is insignificant. Syria's hydropower resources have been practically exhausted; only 150 MW of hydroelectric generation will be installed at the Khabur River, according to the Syrian power plans which extend t0 1990.

1/ Plans have been formulated for interconnecting the networks of Syria and Iraq as well as Iraq and Kuwait. An interconnection scheme between the YAR and the PDRY is being studied by the two governments.

(b) With the exception of Jordan, Lebanon, and the two Yemens, all countries have abundant sources of thermal energy in the form of oil and associated (flared) gas, and some of them have natural gas as well. The four countries that have no resources of their own import petroleum products and use them as their commercial sources of energy. Uranium supplies needed for nuclear plants have not been discovered in the region and therefore will have to be imported.
Table 1.2 (on page 10) to be inserted

The above survey indicates that the hydroelectric power potential in the region is limited, and that the two countries with the greatest hydroelectric power potential (Iraq and Egypt) also possess abundant thermal resources.

The choice between using thermal or nuclear generation rests on economic, technical, and environmental considerations. In order to make comparisons between the two types, one has to analyze the economics of the generating plant, its compatibility with the power system, the complexity of operating and maintaining it, and consequently, the availability of the expertise needed. The following points should be noted:

(i) The cost of uranium[1/] is higher than that of oil or gas at present. However, if the prices of oil and gas continue to rise, the cost gap may eventually narrow to the point where countries without, or with limited thermal resources of their own may decide to resort to nuclear power;

(ii) Only large nuclear plants (typically 600 MW units) have been able to compete cost-wise with other types of plants.These large units require efficient transmission lines and large capacity[2/] networks which do not exist in the region at present. Moreover, the cost of using such large units cannot be justified unless they are connected to large continuous loads. On the other hand, with more research at the manufacturing end, it is possible that smaller units will be produced competitively. Moreover, according to the available data, there will be more integration in the power networks and more inter-connection schemes in the region. Thus, it seems that the unit-size constraint on the use of nuclear plants will cease to be a problem at some point in the future.

1/ The price of uranium has been unstable in the last few years owing to the uncertainty of its suppliers about future nuclear programmes; they have been reluctant to make sizeable investments in mining operations.

2/ As a general rule, the capacity of the largest generating unit should not exceed 7 to 10 per cent of the network's capacity.

(iii) The operation and the maintenance of nuclear plants, compared to other types, require highly skilled personnel. Such a pool of experts does not exist now because this technology has not been introduced into the region.

(iv) Preservation of the environment, a positive feature of nuclear generation, is not a prime concern of the developing countries of ECWA, at least not in the foreseeable future.

From the above discussion, it seems that no large-scale use of nuclear plants is likely to occur in the region during the next two decades.

As a second approach for projecting the future types of generation, the planned and expected[1/] national generation programmes[2/] were extracted from the available date, and the ratios of the various types of generation calculated, as shown in table 1.3. Because the durations of the various programmes vary considerably and none of them cover the entire projection period (to the year 2000), the ratios are significant only in indicating the trend rather than the actual share of the various types of generation. The trend will be towards steam and, to a less extent, gas generation.

Examining table 1.3, one notes that Syria, Egypt, and Iraq are the only countries that have any hydroelectric power programmes, and since those programmes are scheduled to be implemented before 1990, it follows that a good part of the existing hydroelectric power resources will be harnessed before the regional industry matures[3/]. As for nuclear plants, only two countries, Syria and Kuwait, expressed interest in them. Kuwait is interested in a 40-MW plant, which is not economically competitive. Syria has expressed interest in commercial size units (two 600-MW units) which are supposed to be installed around 1990. The table also indicates that the use of diesel generation will be substantially reduced. With the development of integrated national networks, a few small isolated load centres will exist, e.g. for telecommunication stations, and very small communities. Diesel units will be used in these cases, and for stand-by service only.

Based on the discussion so far, it is projected that for the foreseeable future, steam and gas generation will prevail in the region, with steam predominating. One reason for that is related to the economics of unit size.

1/ "Expected" refers to developments which have not been formally planned, yet are expected by the authorities concerned to be included in later plans.

2/ With the exception of the UAE, Saudi Arabia, and Oman for which the available data are inadequate.

3/ The length of the maturation period is about 13 years for turbines and generators, and from 8 to 10 years for transformers.

Table 1.3 Future trend in generation in ECWA Region[a/]

Type of generation		Bahrain	Egypt	Iraq	Jordan	Kuwait	Lebanon	PDRY	Qatar	Syria	YAR
Hydro	(MW)	-	635	1 605	-	-	-	-	-	250	-
Steam	(MW)	480	1 887	3 150	1 024	2 720	438	257[b/]	-	1 860	-[c/]
Gas	(MW)	200	300	-	60	82	-	-	524	-	-
Diesel	(MW)	-	-	-	25	-	-	12	-	-	168
Nuclear	(MW)	-	-	-	-	40	-	-	-	1 200	-
Hydro	(Per cent)	-	22.5	33.8	-	-	-	-	-	7.6	-
Steam	(Per cent)	70.6	66.9	66.2	92.3	95.7	100	95.5[b/]	-	56.2	-[c/]
Gas	(Per cent)	29.4	10.6	-	5.0	2.9	-	-	100	-	-
Diesel	(Per cent)	-	-	-	2.3	-	-	4.5	-	-	100
Nuclear	(Per cent)	1.4	-	-	-	1.4	-	-	-	36.2	-

Source: Joint ECWA/UNIDO Industry Division

a/ Data on other ECWA countries are not available.

b/ After 1978, all generation will be steam.

c/ After 1985, no more diesel plants will be installed. The trend will be towards steam plants.

B. Size of the generating unit

In order to project future unit sizes, a survey of planned and expected generation programmes was conducted. The available data do not cover all countries (e.g. Saudi Arabia), and none of the programmes extend over the entire projection period, therefore, the results shown in table 1.4 can be regarded as broadly indicative of the future trend.

An examination of table 1.4 reveals the following:

(a) The number of unit sizes is large, and the range of their capacities is rather great (30-300 MW for steam, and 20-56 MW for gas). The capacities of most units fall within the 100-300 MW range for steam and 30-50 MW for gas.

(b) Compared to existing units shown in table 1.1, the number of sizes will become smaller and the capacities of the generating units will become larger in the future. Moreover, diesel generation will be practically phased out. These developments are indicative of the future integration of national networks.

Based on the preceding discussion, it seems that the region's future needs can be satisfied by the following unit sizes:

(i) Steam : 100 MW, 150 MW, 300 MW;
(ii) Gas : 50 MW, 100 MW1/.

The standardization of generating units in a few sizes has many operational advantages:

(a) It facilitates the standardization of other equipment in the power system (e.g. transformers, transmission lines, and switchgear);

(b) It reduces operational costs (maintenance, etc.)

From a manufacturing point of view, it results in a more economical operation (fewer designs, less tooling, inventory, testing, etc.).

The use of larger unit sizes in the power system offers economic advantages: lower price and less transportation, installation, operation and maintenance costs (per MW).

From a manufacturing point of view, it is more economical to manufacture one large unit than many smaller units with an equivalent capacity. The cost per MW decreases as the unit size increases because of savings in labour and material costs. This is valid as long as the size does not become very large in which case higher quality and more expensive materials and components and more powerful production equipment and facilities become necessary. The threshold is probably around 500 MW.

1/ In anticipation of more integration in the power network(s) in Saudi Arabia where gas generation is likely to be predominant.

Table 1.4. Planned and expected generating plants in ECWA Region

Type of generation	Bahrain 1978 - 1985	Egypt 1978 - 1985	Iraq 1978 - 1989	Jordan 1978 - 1990	Kuwait 1977 - 2000	Lebanon 1980 - 1983	PDRY 1978 - 1985
Hydro-	none	total 635MW[a]	2 x 80 MW 6 x 100 MW 3 x 115 MW 4 x 125 MW	none	none	none	none
Steam	4 x 70 MW 2 x 100 MW	1 x 87 MW 10 x 150 MW 1 x 300 MW 2 x 110 MW	7 x 150 MW 7 x 300 MW	4 x 33 MW 12 x 66 MW 1 x 100 MW	4 x 80 MW 6 x 150 MW 6 x 300 MW other plants totalling[a] 1,000 MW	3 x 66 MW 2 x 120 MW	2 x 55 MW
Gas	4 x 50 MW	3 x 20 MW 14 x 30 MW	none	3 x 20 MW	2 x 41 MW other plants[a] totalling 700 MW	none	none
Diesel	none	none	none	15 x 0.1 MW 6 x 0.5 MW 3 x 1.5 MW 2 x 3 MW 2 x 5 MW	none	none	none
Nuclear	none	none	none	none	1 x 40 MW 2 x 600 MW	none	none

Table 1.4. (Continued)

Type of generation	Qatar 1977 - 1979	Saudi Arabia	Syria 1978 - 1990	U A E 1979 - 1982	Y A R 1979 - 1985	ECWA Region most popular unit sizes
Hydro-	none	none	1 x 100 MW 1 x 150 MW	none	none	100 MW 125 MW
Steam	none	n.a.	1 x 60 MW 8 x 150 MW 2 x 300 MW	5 x 60 MW 6 x 64.5 MW 4 x 75 MW	3 x 20 MW 3 x 40 MW	150 MW 300 MW
Gas	6 x 50 MW 4 x 56 MW	n.a.	none	1 x 8 MW 2 x 10 MW 2 x 25 MW	none	50 MW 30 MW
Diesel	none	n.a.	none	10 x 0.4 MW 5 x 1.2 MW 1 x 3 MW 2 x 17 MW	3 x 2.5 MW 9 x 5 MW	0.1 MW
Nuclear	none	none	2 x 600 MW	none	none	600 MW

Source : Joint ECWA/UNIDO Industry Division.

a/ : The number of plants and their individual capacities are unknown.

C. Transmission and distribution lines

The planned and expected transmission and distribution lines given in the very limited data available to this study are listed in table 1.5. In spite of the fact that no information is available about some countries (Bahrain, Oman, Saudi Arabia, UAE and YAR), the data indicate that higher transmission voltages are being adopted in the region, e.g., Iraq (400 kV), Kuwait (300 kV), Lebanon (230 kV), PDRY (132 kV).

Table 1.5. Planned and expected transmission and distribution lines(Voltage and length)

	Bahrain	Egypt 1978 - 1985	Iraq 1980 - 1990	Jordan 1978 - 1984	Kuwait 1980 - 1990	Lebanon n.a.
Distribution lines	n.a.	n.a.	n.a.	230/400V n.a. 6.6-11 kV 200km 33-66 kV 1 354km 132 kV	220/415V 14 635km 11 kV 8 060km	n.a.
Transmission lines	n.a.	132 kV 40km 220 kV 1 227km	400kV 3 120km	33-66 kV 1 354km 132 kV 440km	33 kV 2 410km 132 kV 2 125km 300 kV 400km	33 kV 52km 66 kV 80km 150 kV 75km 230 kV 32km

	Oman n.a.	P D R Y n.a.	Qatar 1977 - 1981	Saudi Arabia n.a.	Syria 1976 - 1980	U A E n.a.	Y A R n.a.
Distribution lines	n.a.	240/420V 6 km 11 kV 21 km	n.a. n.a. 11 kV 1 802km	n. a.	n.a. 20 kV 3 500km	n.a.	n.a.
Transmission lines	n.a.	33 kV 93 km 132 kV 65 km	66 kV 392km 132 kV 118km	n. a.	66 kV 2 000km 230 kV 2 250km	n.a.	n.a.

Source : Joint ECWA/UNIDO Industry Division.

CHAPTER 2

GROWTH PROJECTS OF THE REGION'S POWER SYSTEMS AND EQUIPMENT

2.1 General

The power system consists of generating plants, transformer stations, and transmission and distribution lines. In order to project the amount of equipment required in the system (turbines, generators, transformers, switchgear, cables and wires, etc.) it is necessary to project the growth of generation capacity, transformation capacity, and the length of the lines. Because the manufacture of electric power equipment is characterized by long maturation periods, the projection period extends to the year 2000.

The growth of generation and transformation capacities has been projected. Cables and wires associated with transmission and distribution lines are the subject of a separate study by the Joint ECWA/UNIDO Industry Division.

2.2 Generation capacity

The basic parameter for projecting generation capacity is maximum demand. By adding maximum (load) demand to capacity reserve (reserve capacity of the generating plants) and plant auxiliaries, one obtains the generation capacity demand (capacity of the generating plants).

Capacity reserve has two components: spinning reserve which equals the capacity of the largest generating plant in the network, and cold reserve, which normally amounts to 15 per cent of maximum demand. Spinning and cold reserves are lumped together in the ensuing projections and set at 20 per cent of the maximum demand for all countries, except Iraq, for which it was possible to obtain the value of each reserve component separately.

Power house auxiliaries which are not given in the collected data and which add up to an insignificant percentage of generation capacity, are not included in the projections.

The increase in generation capacity demand is satisfied, in practice, by utilizing surplus capacities of existing generating plants and by installing new plants. However, because of the long projection period (1980-2000), it is reasonable to assume that the increase in capacity demand will be satisfied only by installing new plants.

Because the capacity of a generating plant depreciates with time, the depreciation rate[1/] should be taken into account when computing the required capacities of new plants (installed capacity).

The available data do not give maximum demand forecasts over the entire projection period. In fact, for some countries, very limited information is given. Thus it was necessary to make many assumptions in order to complete the maximum demand forecasts.

In order to evaluate the validity of the various assumptions, it was necessary to quantify their effect on the development of all pertinent parameters: generation, losses, consumption, load factor, capacity reserve, and capacity demand. Those parameters are related to one another as follows:

(a) $\text{Load factor (L F)} = \dfrac{\text{Generation}}{\text{maximum demand x 8,760 hours}} \text{ x } 100$

where the L F is expressed as a percentage, generation as MWh, maximum demand as MW, and 8,760 hours is the number of hours per annum.

(b) Consumption equals generation minus losses[2/].

(c) Consumption per capita equals consumption divided by population.

(d) Capacity demand equals maximum demand plus capacity reserve.

The outcome of this process is shown in tables 2.1 to 2.13, corresponding to the 13 countries of ECWA, and in tables 2.14 to 2.16 for the region as a whole. To provide a basis for comparing future projections with actual past performance, table 2.17 was constructed from the most recent electrical statistics available. Population projections are given in table 2.18. The process and results for each country described in the following paragraphs.

Bahrain (see table 2.1)

Maximum demand, load factor, generation, losses and sales during 1977-1986 were forecast by the Arab Fund for Economic and Social Development (AFSED).

We assume that during 1987-1990 the growth rate of maximum demand will be 12 per cent which is consistent with the decreasing trend during the previous period. From 1991 to 2000 it will substantially decrease to 5 per cent which is slightly higher than the projected rate of population

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1/ Reflecting the useful life of the plant which is approximately 40 years for Hydro, 25 years for Steam, and 15 years for Gas.

2/ In the entire network (generating plant, transformers, transmission and distribution lines).

Table 2.1 Estimated Generation Capacity Demand (1980-2000) Bahrain

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Generation	(GWh)	1 572	1 772	1 984	2 220	2 488	2 788	3 064	3 435	3 847	4 307	4 824
Annual increase	(GWh)	236	200	212	236	268	300	276	371	412	460	517
Annual increase	(%)	18	13	12	12	12	12	10	12	12	12	12
Average annual increase	(%)				(13.2)					(11.6)		
Losses	(%)	9	10	10	10	10	10	10	10	10	10	10
	(GWh)	149	177	198	222	249	279	322	343	385	431	482
Consumption	(GWh)	1 423	1 595	1 786	1 998	2 239	2 509	2 742	3 092	3 462	3 876	4 342
Annual increase	(GWh)	214	172	191	212	241	270	233	350	370	414	466
Annual increase	(%)	18	12	12	12	12	12	9	13	12	12	12
Average annual increase	(%)				(12.0)					(11.6)		
Per capita	(kWh)	4 840	5 624	5 706	6 185	6 704	7 294	7 724	8 425	9 159	9 938	10 774
Load Factor	(%)	46	46	46	46	46	46	46	46	46	46	46
Maximum Demand	(MW)	393	443	496	555	622	697	766	858	961	1 076	1 205
Annual increase	(MW)	59	50	53	59	67	75	69	92	103	115	129
Annual increase	(%)	18	13	12	12	12	12	10	12	12	12	12
Average annual increase	(%)				(12.2)					(11.6)		
Capacity Reserve	(%)	20	20	20	20	20	20	20	20	20	20	20
	(MW)	79	89	99	111	124	139	153	172	192	215	241
Capacity Demand	(MW)	472	532	595	666	746	836	919	1 030	1 153	1 291	1 446
Annual increase	(MW)	71	60	63	71	80	90	83	111	123	138	155
Annual increase	(%)	18	13	12	12	12	12	10	12	12	12	12
Average annual increase	(%)				(12.2)					(11.6)		
Average annual increase	(MW)				(73)					(122)		

Table 2.1. (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Generation	(GWh)	5 541	5 817	6 106	6 412	6 732	7 069	7 424	7 796	8 186	8 594
Annual increase	(GWh)	717	276	289	306	320	337	355	372	390	408
Annual increase	(%)	15	5	5	5	5	5	5	5	5	5
Average annual increase	(%)			(7)					(5)		
Losses	(%)	10	10	10	10	10	10	10	10	10	10
	(GWh)	554	582	611	641	673	707	742	780	819	859
Consumption	(GWh)	4 987	5 235	5 495	5 771	6 059	6 362	6 682	7 016	7 367	7 735
Annual increase	(GWh)	645	248	260	276	288	303	320	334	351	368
Annual increase	(%)	15	5	5	5	5	5	5	5	5	5
Average annual increase	(%)			(7)					(5)		
Per capita	(kWh)	12 017	12 260	12 489	12 711	12 947	13 227	13 526	13 811	14 113	14 431
Load Factor	(%)	50	50	50	50	50	50	50	50	50	50
Maximum Demand	(MW)	1 265	1 328	1 394	1 464	1 537	1 614	1 695	1 780	1 869	1 962
Annual increase	(MW)	60	63	66	70	73	77	81	85	89	93
Annual increase	(%)	5	5	5	5	5	5	5	5	5	5
Average annual increase	(%)			(5)					(5)		
Capacity Reserve	(%)	20	20	20	20	200	20	20	20	20	20
	(MW)	253	266	279	293	307	323	339	356	374	392
Capacity Demand	(MW)	1 518	1 594	1 673	1 757	1 844	1 937	2 034	2 136	2 243	2 354
Annual increase	(MW)	72	76	79	84	87	93	97	102	107	111
Annual increase	(%)	5	5	5	5	5	5	5	5	5	5
Average annual increase	(%)			(5)					(5)		
Average annual increase	(MW)			(80)					(102)		

Source: Joint ECWA/UNIDO Industry Division.

growth during that period, and indicates that a state of consumption saturation[1/] is being reached.

The load factor (L F) was assumed to be 46 per cent in the AFSED forecast. We assume that the L F will be maintained at that level until 1990, thereafter rising to 50 per cent, which is comparable to the load factors in other Gulf countries.

Losses were assumed to be 10 per cent in the AFESD forecast, indicating that the power system in Bahrain is the most efficient in the ECWA region. We assume that the same loss rate will be maintained over the entire projection period.

The projected avergae annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
73 MW	122 MW	80 MW	102 MW

Egypt (See table 2.2)

The forecast of maximum demand, generation and load factor up to the year 2000 was made by the International Bank for Reconstruction and Development (IBRD). The forecasted load factor was the highest in the region indicating a high share of industrial load[2/]. Losses were assumed in the forecast to be 17 per cent during 1978-1985. We assume the same rate will be maintained until 1990, and will decrease slightly to 15 per cent during 1991-2000.

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
372 MW	853 MW	724 MW	959 MW

Iraq (See table 2.3)

The forecast of maximum demand, generation and capacity reserve (both spinning and cold) up to the year 1993 was prepared by the National Electricity Administration. Although that forecast was made in 1973 and might have been modified since then, it is the most up to date information available at the present. The average value of the load factor during that period was calculated to be about 55 per cent which was equivalent to that of previous years.

1/ Consumption is considered to have reached saturation whenever the per capita consumption reaches 10,000 to 15,000 kWh, which is the rate in the most developed countries.

2/ Industrial consumption amounted to 60 per cent of total consumption during 1976-1977.

Table 2.2. Estimated generation capacity demand 1980-2000 Egypt

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Generation	(GWh)	20 669	22 136	23 717	25 427	27 157	29 125	32 053	35 263	38 819	42 711	47 002
Annual increase	(GWh)	1 165	1 467	1 581	1 710	1 730	1 968	2 928	3 210	3 556	3 892	4 291
Annual increase	(%)	6	7	7	7	7	7	10	10	10	10	10
Average annual increase	(%)				(7)					(10)		
Losses	(%)	17	17	17	17	17	17	17	17	17	17	17
	(GWh)	3 513	3 763	4 032	4 322	4 616	4 951	5 449	5 994	6 599	7 260	7 990
Consumption	(GWh)	17 156	18 373	19 685	21 105	22 541	24 174	26 604	29 269	32 220	35 451	39 012
Annual increase	(GWh)	967	1 217	1 313	1 419	1 436	1 633	2 430	2 665	2 951	3 231	3 561
Annual increase	(%)	6	7	7	7	7	7	10	10	10	10	10
Average annual increase	(%)				(7)					(10)		
Per capita	(kWh)	414	434	455	477	499	524	564	607	654	704	758
Load factor	(%)	72	72	72	71	69	68	67	66	65	64	64
Maximum demand	(MW)	3 282	3 516	3 766	4 091	4 445	4 831	5 392	6 019	6 720	7 505	8 383
Annual increase	(MW)	185	234	250	325	354	386	561	627	701	785	878
Annual increase	(%)	6	7	7	9	9	9	12	12	12	12	12
Average annual increase	(%)				(8.2)					(12)		
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20	20
	(MW)	656	703	753	818	889	966	1 078	1 204	1 344	1 501	1 677
Capacity demand	(MW)	3 938	4 219	4 519	4 909	5 334	5 797	6 470	7 223	8 064	9 006	10 060
Annual increase	(MW)	222	281	300	390	425	463	673	753	841	942	1 054
Annual increase	(%)	6	7	7	9	9	9	12	12	12	12	12
Average annual increase	(%)				(8.2)					(12)		
Average annual increase	(MW)				(372)					(853)		

(Continued..)

Table 2.2. (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Generation	(GWh)	49 985	53 141	56 517	60 094	63 907	67 865	72 064	76 533	81 276	86 306
Annual increase	(GWh)	2 983	3 156	3 376	3 577	3 813	3 958	4 199	4 469	4 743	5 030
Annual increase	(%)	6	6	6	6	6	6	6	6	6	6
Average annual increase	(%)			(6)					(6)		
Losses	(%)	15	15	15	15	15	15	15	15	15	15
	(GWh)	7 498	7 971	8 478	9 014	9 586	10 180	10 800	11 480	12 191	12 946
Consumption	(GWh)	42 487	45 170	48 039	51 080	54 321	57 685	61 254	65 053	69 085	73 360
Annual increase	(GWh)	3 475	2 683	2 869	3 041	3 241	3 364	3 569	3 799	4 032	4 275
Annual increase	(%)	9	6	6	6	6	6	6	6	6	6
Average annual increase	(%)			(6.5)					(6)		
Per capita	(kWh)	808	841	875	910	947	984	1 023	1 063	1 104	1 147
Load factor	(%)	64	64	64	64	64	64	64	64	64	64
Maximum demand	(MW)	8 914	9 479	10 080	10 719	11 398	12 104	12 853	13 650	14 495	15 393
Annual increase	(MW)	531	565	601	639	679	706	749	797	845	898
Annual increase	(%)	6	6	6	6	6	6	6	6	6	6
Average annual increase	(%)			(6)					(6)		
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20
	(MW)	1 783	1 896	2 016	2 144	2 280	2 421	2 571	2 730	2 899	3 079
Capacity demand	(MW)	10 697	11 375	12 096	12 863	13 678	14 525	15 424	16 380	17 394	18 472
Annual increase	(MW)	637	678	721	767	815	847	899	956	1 014	1 078
Annual increase	(%)	6	6	6	6	6	6	6	6	6	6
Average annual increase	(%)			(6)					(6)		
Average annual increase	(MW)			(724)					(959)		

Source: Joint ECWA/UNIDO Industry Division.

From 1994 to 2000, we have assumed a slight decline in the growth rate of maximum demand. This is consistent with the trend towards the end of the 1980-1993 period, which probably indicates the consolidation of the generation programmes. A slight increase in the load factor is assumed during 1994-2000 indicating an expected increase in the industrial share of the load.

Losses were assumed to be 10 per cent which is equal to the 1966-1973 average rate as calculated from the available data. This rate is one of the lowest in the region, implying an efficient power system; we have decided to maintain it during the entire projection period.

It is assumed that spinning reserve will be 300 MW during 1994-2000, while cold reserve will stay at 15 per cent.

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
341 MW	552 MW	901 MW	1,461 MW

Jordan (See table 2.4)1/

The forecast of maximum demand and generation during 1977-1995 was prepared by the Jordan Electricity Authority. The corresponding load factor was calculated and found to average 61 per cent which fell within the range of load factors of previous years.

It is assumed that the growth rate of maximum demand during 1996-2000 will be 10 per cent, i.e. equivalent to the 1991-1995 growth rate assumed by the Jordan Electricity Authority forecast. It is assumed that the load factor during 1996-2000 will be 63 per cent; the slight increase is consistent with the trend during the previous period and indicates an expected increasing share of load by industry. It is assumed that losses will be 12 per cent throughout the entire projection period, which is equal to the average loss rate during 1971-1976.

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
50 MW	61 MW	102 MW	161 MW

1/ All values shown in table 2.4 apply to the East Bank only; electrical data on the West Bank of Jordan are not available.

Table 2.3. Estimated generation capacity demand, 1980-2000 Iraq

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Generation	(GWh)	7 759	8 745	9 882	11 163	12 883	14 516	16 404	18 553	20 999	23 459	26 274
Annual increase	(GWh)	1 033	986	1 137	1 281	1 720	1 633	1 888	2 149	2 446	2 460	2 815
Annual increase	(%)	15	13	13	13	15	13	13	13	13	12	12
Average annual increase	(%)	←			(13.4)		→	←		(12.6)		→
Losses	(%)	10	10	10	10	10	10	10	10	10	10	10
	(GWh)	776	875	988	1 116	1 288	1 452	1 640	1 855	2 100	2 345	2 627
Consumption	(GWh)	6 983	7 870	8 894	10 047	11 595	13 064	14 764	16 698	18 899	21 113	23 646
Annual increase	(GWh)	930	887	1 024	1 153	1 548	1 469	1 700	1 934	2 201	2 214	2 533
Annual increase	(%)	15	13	13	13	15	13	13	13	13	12	12
Average annual increase	(%)	←			(13.4)		→	←		(12.6)		→
Per capita	(kWh)	533	581	636	695	777	847	927	1 015	1 112	1 202	1 294
Load factor	(%)	55	49	55	55	56	56	56	56	56	56	56
Maximum demand	(MW)	1 606	1 815	2 051	2 317	2 619	2 959	3 344	3 778	4 269	4 782	5 356
Annual increase	(MW)	210	209	236	266	302	340	385	434	491	513	514
Annual increase	(%)	15	13	13	13	13	13	13	13	13	12	12
Average annual increase	(%)	←			(13)		→	←		(12.6)		→
Capacity reserve												
Spinning reserve	(MW)	150	150	150	300	300	300	300	300	300	300	300
Cold reserve	(%)	15	15	15	15	15	15	15	15	15	15	15
Cold reserve	(MW)	241	272	308	348	393	444	502	567	641	717	803
Total	(MW)	391	422	458	648	693	744	802	867	941	1 017	1 103
Capacity demand	(MW)	1 997	2 237	2 509	2 965	3 312	3 703	4 146	4 645	5 210	5 799	6 459
Annual increase	(MW)	242	240	272	456	347	391	443	499	565	589	660
Annual increase	(%)	14	12	12	18	12	12	12	12	12	11	11
Average annual increase	(%)	←			(13.2)		→	←		(11.6)		→
Average annual increase	(MW)	←			(341)		→	←		(552)		→

Table 2.3. (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Generation	(GWh)	29 424	32 956	36 910	41 703	46 292	51 385	57 037	63 314	70 279	78 009
Annual increase	(GWh)	3 150	3 532	3 954	4 793	4 589	5 093	5 652	6 277	6 965	7 730
Annual increase	(%)	12	12	12	13	11	11	11	11	11	11
Average annual increase	(%)	←		(12)		→	←		(11)		→
Losses	(%)	10	10	10	10	10	10	10	10	10	10
	(GWh)	2 942	3 296	3 691	4 170	4 629	5 138	5 704	6 331	7 028	7 801
Consumption	(GWh)	26 482	29 660	33 219	37 533	41 633	46 247	51 333	56 983	63 251	70 208
Annual increase	(GWh)	2 836	3 178	3 559	4 314	4 130	4 584	5 086	5 650	6 268	6 957
Annual increase	(%)	12	12	12	12	11	11	11	11	11	11
Average annual increase	(%)	←		(11.8)		→	←		(11)		→
Per capita	(kWh)	1 414	1 533	1 662	1 818	1 954	2 099	2 256	2 424	2 605	2 799
Load factor	(%)	56	56	56	57	57	57	57	57	57	57
Maximum demand	(MW)	5 998	6 718	7 524	8 352	9 271	10 291	11 423	12 680	14 075	15 623
Annual increase	(MW)	642	720	806	828	919	1 020	1 132	1 257	1 395	1 548
Annual increase	(%)	12	12	12	11	11	11	11	11	11	11
Average annual increase	(%)	←		(11.6)		→	←		(11)		→
Capacity reserve											
Spinning reserve	(MW)	300	300	300	300	300	300	300	300	300	300
Cold reserve	(%)	15	15	15	15	15	15	15	15	15	15
Cold reserve	(MW)	900	1 008	1 129	1 253	1 391	1 544	1 713	1 902	2 111	2 343
Total	(MW)	1 200	1 308	1 429	1 553	1 691	1 844	2 013	2 202	2 411	2 643
Capacity demand	(MW)	7 198	8 026	8 953	9 905	10 962	12 135	13 436	14 882	16 486	18 266
Annual increase	(MW)	739	828	927	952	1 057	1 173	1 301	1 446	1 604	1 780
Annual increase	(%)	11	11	11	11	11	11	11	11	11	11
Average annual increase	(%)			(11)		→			(11)		→
Average annual increase	(MW)			(901)		→			(1 461)		→

Source: Joint ECWA/UNIDO Industry Division.

Table 2.4. Estimated generation capacity demand,1980-2000
Jordan (East Bank only)

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Generation	(GWh)	1 051	1 272	1 664	1 789	1 972	2 269	2 476	2 745	3 014	3 302	3 664
Annual increase	(GWh)	176	221	392	125	183	297	207	269	269	288	362
Annual increase	(%)	20	21	31	8	10	15	9	11	10	10	11
Average annual increase	(%)	←		(17)		→	←		(10.2)			→
Losses	(%)	12	12	12	12	12	12	12	12	12	12	12
	(GWh)	126	153	200	215	237	272	297	329	362	397	440
Consumption	(GWh)	925	1 119	1 464	1 574	1 735	1 997	2 179	2 416	2 652	2 905	3 224
Annual increase	(GWh)	155	194	345	110	161	262	200	237	236	253	319
Annual increase	(%)	20	21	31	8	10	15	10	11	10	10	11
Average annual increase	(%)	←		(17)		→	←		(10.4)			→
Per capita	(kWh)	432	506	641	667	712	793	838	899	955	1 013	1 088
Load Factor	(%)	56	55	60	60	61	61	61	61	63	61	62
Maximum Demand	(MW)	213	262	314	338	371	421	461	513	546	622	677
Annual increase	(MW)	47	49	52	24	33	50	40	52	33	76	55
Annual increase	(%)	28	23	20	8	10	13	10	11	6	14	9
Average annual increase	(%)	←		(14.8)		→	←		(10)			→
Capacity Reserve	(%)	20	20	20	20	20	20	20	20	20	20	20
	(MW)	43	52	63	68	74	84	92	103	109	124	135
Capacity Demand	(MW)	256	314	377	406	445	505	553	616	655	746	812
Annual increase	(MW)	57	58	63	29	39	60	48	63	39	91	66
Annual increase	(%)	29	23	20	8	10	13	10	11	6	14	9
Average annual increase	(%)	←		(14.8)		→	←		(10)			→
Average annual increase	(MW)	←		(50)		→	←		(61)			→

Table 2.4, (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Generation	(GWh)	4 098	4 508	4 958	5 454	6 000	6 678	7 346	8 080	8 885	9 774
Annual increase	(GWh)	434	410	450	496	546	678	668	734	805	889
Annual increase	(%)	12	10	10	10	10	11	10	10	10	10
Average annual increase	(%)	←		(10.4)		→	←		(10.2)		→
Losses	(%)	12	12	12	12	12	12	12	12	12	12
	(GWh)	492	541	595	654	720	801	882	970	1 066	1 173
Consumption	(GWh)	3 606	3 967	4 363	4 800	5 280	5 877	6 464	7 110	7 819	8 601
Annual increase	(GWh)	382	361	396	437	480	597	587	646	709	782
Annual increase	(%)	12	10	10	10	10	11	10	10	10	10
Average annual increase	(%)	←		(10.4)		→	←		(10.2)		→
Per capita	(kWh)	1 179	1 255	1 336	1 423	1 516	1 633	1 739	1 851	1 971	2 099
Load Factor	(%)	63	63	63	62	62	63	63	63	63	63
Maximum Demand	(MW)	745	820	900	1 000	1 100	1 210	1 331	1 464	1 610	1 771
Annual increase	(MW)	68	75	80	100	100	110	121	133	146	161
Annual increase	(%)	10	10	10	11	10	10	10	10	10	10
Average annual increase	(%)	←		(10.2)		→	←		(10)		→
Capacity Reserve	(%)	20	20	20	20	20	20	20	20	20	20
	(MW)	149	164	180	200	220	242	266	293	322	354
Capacity Demand	(MW)	894	984	1 080	1 200	1 320	1 452	1 597	1 757	1 932	2 125
Annual increase	(MW)	82	90	96	120	120	132	145	160	175	193
Annual increase	(%)	10	10	10	11	10	10	10	10	10	10
Average annual increase	(%)	←		(10.2)		→	←		(10)		→
Average annual increase	(MW)	←		(102)		→	←		(161)		→

Source: Joint ECWA/UNIDO Industry Division.

Table 2.5. Estimated generation capacity demand 1980-2000 Kuwait

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Generation	(GWh)	9 636	10 582	11 616	12 755	14 003	15 330	16 784	18 383	20 126	22 040	24 090
Annual increase	(GWh)	1 183	946	1 034	1 139	1 248	1 327	1 454	1 599	1 743	1 914	2 050
Annual increase	(%)	14	10	10	10	10	10	10	10	10	10	9
Average annual increase	(%)			(10)						(9.8)		
Losses	(%)	15	15	15	15	15	15	15	15	15	15	15
	(GWh)	1 445	1 587	1 742	1 913	2 100	2 299	2 518	2 757	3 019	3 306	3 613
Consumption	(GWh)	8 191	8 995	9 874	10 842	11 903	13 031	14 266	15 626	17 107	18 734	20 477
Annual increase	(GWh)	1 006	804	879	968	1 061	1 128	1 235	1 360	1 481	1 627	1 743
Annual increase	(%)	14	10	10	10	10	10	10	10	10	10	9
Average annual increase	(%)			(10)						(9.8)		
Per capita	(kWh)	5 706	5 957	6 238	6 535	6 849	7 152	7 524	7 916	8 325	8 758	9 195
Load factor	(%)	50	50	50	50	50	50	50	50	50	50	50
Maximum demand	(MW)	2 200	2 416	2 652	2 912	3 197	3 500	3 832	4 197	4 595	5 032	5 500
Annual increase	(MW)	270	216	236	260	285	303	332	365	398	437	468
Annual increase	(%)	14	10	10	10	10	10	10	10	10	10	9
Average annual increase	(%)			(10)						(9.8)		
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20	20
	(MW)	440	483	530	582	639	700	766	839	919	1 006	1 100
Capacity demand	(MW)	2 640	2 899	3 182	3 494	3 836	4 200	4 598	5 036	5 514	6 038	6 600
Annual increase	(MW)	324	259	283	312	342	364	398	438	478	524	562
Annual increase	(%)	14	10	10	10	10	10	10	10	10	10	9
Average annual increase	(%)			(10)						(9.8)		
Average annual increase	(MW)			(312)						(480)		

"Continued"

Table 2.5. (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Generation	(GWh)	27 105	28 771	30 540	32 421	34 412	36 530	38 777	41 163	43 693	46 428
Annual increase	(GWh)	3 015	1 666	1 769	1 881	1 991	2 118	2 247	2 386	2 530	2 735
Annual increase	(%)	12	6	6	6	6	6	6	6	6	6
Average annual increase	(%)	←		(7.2)		→	←		(6)		→
Losses	(%)	12	12	12	12	12	12	12	12	12	12
	(GWh)	3 253	3 453	3 665	3 891	4 129	4 384	4 653	4 940	5 243	5 571
Consumption	(GWh)	23 852	25 318	26 875	28 530	30 282	32 146	34 124	36 223	38 450	40 857
Annual increase	(GWh)	3 375	1 466	1 557	1 655	1 752	1 864	1 978	2 099	2 227	2 407
Annual increase	(%)	16	6	6	6	6	6	6	6	6	6
Average annual increase	(%)	←		(8)		→	←		(6)		→
Per capita	(kWh)	10 317	10 553	10 789	11 037	11 286	11 542	11 804	12 070	12 343	12 634
Load Factor	(%)	53	53	53	53	53	53	53	53	53	53
Maximum Demand	(MW)	5 838	6 197	6 578	6 983	7 412	7 868	8 352	8 866	9 411	10 000
Annual increase	(MW)	338	359	381	405	429	456	484	514	545	589
Annual increase	(%)	6	6	6	6	6	6	6	6	6	6
Average annual increase	(%)	←		(6)		→	←		(6)		→
Capacity Reserve	(%)	20	20	20	20	20	20	20	20	20	20
	(MW)	1 168	1 239	1 316	1 397	1 482	1 574	1 670	1 773	1 882	2 000
Capacity Demand	(MW)	7 006	7 436	7 893	8 379	8 894	9 442	10 022	10 639	11 293	12 000
Annual increase	(MW)	406	430	457	486	515	548	580	617	654	707
Annual increase	(%)	6	6	6	6	6	6	6	6	6	6
Average annual increase	(%)	←		(6)		→	←		(6)		→
Average annual increase	(MW)	←		(459)		→	←		(621)		→

Source: Joint ECWA/UNIDO Industry Division.

Kuwait (See table 2.5)

The forecast of maximum demand and generation capacity demand in Kuwait up to the year 2000 was prepared by the Ministry of Electricity. The annual rate of increase in consumption was projected as follows: about 10 per cent during 1981-1990, and 6 per cent during 1991-2000 which represents the universally accepted "natural growth rate".

We assume a load factor of 50 per cent during 1980-1990 which is equivalent to the load factor during the 1970s. During 1991-2000, it is estimated that the L F will be 53 per cent which represents a slight increase due to expected industrial projects.

It is assumed that losses will be 15 per cent during 1980-1990, thereafter decreasing to 12 per cent.

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
312 MW	480 MW	459 MW	621 MW

Lebanon (See table 2.6)

The available data on Lebanon consist of two demand forecasts for the period 1977-1983. One forecast was made by Electricite de France (EDF) and the other by the AFESD. The differences between the two forecasts are insignificant.

The two forecasts start with low demand figures which reflect the adverse effect of the 1975-1976 disturbances upon the country. The demand estimates for 1977 and 1978 are almost identical to the actual loads in 1973 and 1974 respectively. This situation was confirmed by officials of Electricite Du Liban (EDL).

Because the two forecasts are confined to the EDL network, which does not cover the entire country, they were not used. Instead, we extracted the 1973 demand figures for the whole of Lebanon from the data available and used them for 1977. Further, the growth rate of generation during 1966-1973 was computed and found to be 15 per cent per annum. We assume that this rate will be maintained throughout the projection period.

Based on calculated past rates, it is assumed that the load factor will be 55 per cent during 1980-1990, increasing slightly to 56 per cent during 1991-2000.

It is assumed that losses during 1980-1990 will be 12 per cent, which is equivalent to the rate during previous years, and indicates an efficient power system. It is assumed that this will decrease to 10 per cent during 1991-2000, and it is expected that this system will continue to be one of the most efficient in the region.

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
137 MW	276 MW	555 MW	1,125 MW

Oman (See table 2.7)

The data available on Oman is inadequate; it consists mainly of a forecast made by IDCAS, extending to 1978 only. Thus, the projections on Oman are very crude. However, their impact on the overall capacity demand in the region is insignificant.

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
13 MW	13 MW	16 MW	20 MW

People's Democratic Republic of Yemen (PDRY) (See table 2.8)

There are two forecasts of maximum demand and generation available. One was made by the AFESD in 1975 and extends to 1985; the other was made by the Abu Dhabi Fund in 1976 and extends to 1990. We chose to use the latter forecast because the former seemed to be overly conservative: annual increase in maximum demand was estimated to be 2 per cent in 1980, 1981 and 1982 and 1 per cent in 1984 and 1985. The Abu Dhabi forecast gives low, medium, and high projections. Medium projections are used in this study. During 1991-2000 it is assumed that the average annual increase in maximum demand will be 10 per cent.

It is assumed that losses will be 17 per cent during 1980-1991 which is consistent with past performance from 1971-1975. They are expected to decrease to 15 per cent during the following decade.

The load factor during 1980-1990 was calculated from the above forecast and found to average about 60 per cent. It is expected to maintain that level during the following decade.

The poor state of the power system is clearly manifested by the per capita consumption rate which at 384 kWh by the year 2000 will still be lower than present rates in most countries of the region.

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
7 MW	10 MW	17 MW	24 MW

Table 2.6. Estimated generation capacity demand, 1980-2000 Lebanon

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Generation	(GWh)	2 722	3 132	3 604	4 143	4 765	5 478	6 302	7 246	8 335	9 588	11 024
Annual increase	(GWh)	356	410	472	539	622	713	824	944	1 089	1 253	1 436
Annual increase	(%)	15	15	15	15	15	15	15	15	15	15	15
Average annual increase	(%)	←			(15)		→	←		(15)		→
Losses	(%)	12	12	12	12	12	12	12	12	12	12	12
	(GWh)	327	376	433	497	572	675	756	870	1 000	1 151	1 323
Consumption	(GWh)	2 395	2 756	3 171	3 646	4 193	4 803	5 546	6 376	7 335	8 437	9 701
Annual increase	(GWh)	313	361	415	475	547	610	743	830	959	1 102	1 264
Annual increase	(%)	15	15	15	15	15	15	15	15	15	15	15
Average annual increase	(%)	←			(15)		→	←		(15)		→
Per capita	(kWh)	719	802	894	996	1 110	1 232	1 379	1 536	1 712	1 908	2 126
Load factor	(%)	55	55	55	55	55	55	55	55	55	55	55
Maximum demand	(MW)	565	650	748	860	989	1 137	1 308	1 504	1 730	1 990	2 288
Annual increase	(MW)	74	85	98	112	129	148	171	196	226	260	298
Annual increase	(%)	15	15	15	15	15	15	15	15	15	15	15
Average annual increase	(%)	←			(15)		→	←		(15)		→
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20	20
	(MW)	113	130	150	172	198	227	262	301	346	398	458
Capacity demand	(MW)	678	780	898	1 032	1 187	1 364	1 570	1 805	2 076	2 388	2 746
Annual increase	(MW)	89	102	118	134	155	177	206	235	271	312	358
Annual increase	(%)	15	15	15	15	15	15	15	15	15	15	15
Average annual increase	(%)	←			(15)		→	←		(15)		→
Average annual increase	(MW)	←			(137)		→	←		(276)		→

Table 2.6. (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
<u>Generation</u>	(GWh)	12 910	14 844	17 071	19 632	22 576	25 960	29 855	34 334	39 485	45 406
Annual increase	(GWh)	1 886	1 934	2 227	2 561	2 944	3 384	3 895	4 479	5 151	5 921
Annual increase	(%)	17	15	15	15	15	15	15	15	15	15
Average annual increase	(%)			(15.4)					(15)		
<u>Losses</u>	(%)	10	10	10	10	10	10	10	10	10	10
	(GWh)	1 291	1 484	1 707	1 963	2 258	2 596	2 985	3 433	3 948	4 540
Consumption	(GWh)	11 619	13 360	15 364	17 669	20 318	23 364	26 870	30 901	35 537	40 866
Annual increase	(GWh)	1 918	1 741	2 004	2 305	2 649	3 046	3 506	4 031	4 636	5 329
Annual increase	(%)	20	15	15	15	15	15	15	15	15	15
Average annual increase	(%)			(16)					(15)		
Per capita	(kWh)	2 472	2 760	3 081	3 441	3 841	4 288	4 788	5 346	5 969	6 664
<u>Load factor</u>	(%)	56	56	56	56	56	56	56	56	56	56
<u>Maximum demand</u>	(MW)	2 631	3 026	3 480	4 002	4 602	5 292	6 086	6 999	8 049	9 256
Annual increase	(MW)	343	395	454	522	600	690	794	913	1 050	1 207
Annual increase	(%)	15	15	15	15	15	15	15	15	15	15
Average annual increase	(%)			(15)					(15)		
<u>Capacity reserve</u>	(%)	20	20	20	20	20	20	20	20	20	20
	(MW)	526	605	696	801	920	1 058	1 217	1 400	1 610	1 851
<u>Capacity demand</u>	(MW)	3 157	3 631	4 176	4 802	5 522	6 350	7 303	8 399	9 659	11 107
Annual increase	(MW)	411	474	545	626	720	828	953	1 096	1 260	1 488
Annual increase	(%)	15	15	15	15	15	15	15	15	15	15
Average annual increase	(%)			(15)					(15)		
Average annual increase	(MW)			(555)					(1 125)		

<u>Source</u>: Joint ECWA/UNIDO Industry Division.

Table 2.7. Estimated generation capacity demand, 1980-2000 Oman

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
<u>Generation</u>	(GWh)	562	603	648	696	748	800	844	891	939	991	1 046
Annual increase	(GWh)	44	41	45	48	52	52	44	47	48	52	55
Annual increase	(%)	8	7	7	7	7	7	6	6	5	6	6
Average annual increase	(%)	←			(7)		→	←		(5.8)		→
<u>Losses</u>	(%)	15	15	15	15	15	15	15	15	15	15	15
	(GWh)	84	90	97	104	112	120	127	134	141	149	157
<u>Consumption</u>	(GWh)	478	513	551	592	636	680	717	757	798	842	889
Annual increase	(GWh)	38	35	38	41	44	44	37	40	41	44	47
Annual increase	(%)	9	7	7	7	7	7	5	6	5	6	6
Average annual increase	(%)	←			(7)		→	←		(5.6)		→
Per capita	(kWh)	532	553	576	599	623	646	660	675	690	705	722
Load factor	(%)	50	50	50	50	50	50	50	50	50	50	50
<u>Maximum demand</u>	(MW)	128	138	148	159	171	183	193	203	214	226	239
Annual increase	(MW)	10	10	10	11	12	12	10	10	11	12	13
Annual increase	(%)	8	8	7	7	8	7	5	5	5	6	6
Average annual increase	(%)	←			(7.4)		→	←		(5.4)		→
<u>Capacity reserve</u>	(%)	20	20	20	20	20	20	20	20	20	20	20
	(MW)	26	28	30	32	34	37	39	41	43	45	48
<u>Capacity demand</u>	(MW)	154	166	178	191	205	220	232	244	257	271	287
Annual increase	(MW)	12	12	12	13	14	15	12	12	13	14	16
Annual increase	(%)	8	8	7	7	7	7	5	5	5	5	6
Average annual increase	(%)	←			(7.2)		→	←		(5.2)		→
Average annual increase	(MW)	←			(13)		→	←		(13)		→

Table 2.7. (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Generation	(GWh)	1 099	1 155	1 214	1 275	1 341	1 408	1 478	1 552	1 630	1 712
Annual increase	(GWh)	53	56	59	61	66	67	70	74	78	82
Annual increase	(%)	5	5	5	5	5	5	5	5	5	5
Average annual increase	(%)			(5)					(5)		
Losses in	(%)	15	15	15	15	15	15	15	15	15	15
Losses in	(GWh)	165	173	182	191	201	211	222	233	245	257
Consumption	(GWh)	934	982	1 032	1 084	1 140	1 197	1 256	1 319	1 385	1 455
Annual increase	(GWh)	45	48	50	52	56	57	59	63	66	70
Annual increase	(%)	5	5	5	5	5	5	5	5	5	5
Average annual increase	(%)			(5)					(5)		
Per capita	(kWh)	736	752	767	782	798	815	832	850	868	888
Load factor	(%)	50	50	50	50	50	50	50	50	50	50
Maximum demand	(MW)	251	264	277	291	306	321	337	354	372	391
Annual increase	(MW)	12	13	13	14	15	15	16	17	18	19
Annual increase	(%)	5	5	5	5	5	5	5	5	5	5
Average annual increase	(%)			(5)					(5)		
Capacity reserve in	(%)	20	20	20	20	20	20	20	20	20	20
Capacity reserve in	(MW)	50	53	55	58	61	64	67	71	74	78
Capacity demand	(MW)	301	317	332	349	367	385	404	425	446	469
Annual increase	(MW)	14	16	15	17	18	18	19	21	21	23
Average annual increase	(%)			(5)					(5)		
Average annual increase	(MW)			(16)					(20)		

Source: Joint ECWA/UNIDO Industry Division.

Table 2.8. Estimated generation capacity demand, 1980-2000
People's Democratic Republic of Yemen (PDRY)

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Generation	(GWh)	256	288	320	351	386	422	461	502	546	593	644
Annual increase	(GWh)	30	32	32	31	35	36	39	41	44	47	51
Annual increase	(%)	13	12	11	10	10	9	9	9	9	9	9
Average annual increase	(%)				(10.4)					(9)		
Losses	(%)	17	17	17	17	17	17	17	17	17	17	17
	(GWh)	44	49	54	60	66	72	78	85	93	101	109
Consumption	(GWh)	212	239	266	291	320	350	383	417	453	492	535
Annual increase	(GWh)	24	27	27	25	29	30	33	34	36	39	43
Annual increase	(%)	13	12	11	10	9	9	9	9	9	9	9
Average annual increase	(%)				(10.2)					(9)		
Per capita	(kWh)	107	117	126	134	143	152	161	170	179	189	199
Load factor	(%)	60	59	60	60	60	60	60	60	60	60	61
Maximum demand	(MW)	49	56	61	67	74	80	88	96	104	113	121
Annual increase	(MW)	6	7	5	6	7	6	8	8	8	9	8
Annual increase	(%)	14	14	9	10	10	8	10	9	8	9	7
Average annual increase	(%)				(10.2)					(8.6)		
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20	20
	(MW)	10	11	12	13	15	16	18	19	21	23	24
Capacity demand	(MW)	59	67	73	80	88	196	106	115	125	136	145
Annual increase	(MW)	7	8	6	7	8	8	10	10	10	11	10
Annual increase	(%)	14	14	9	10	10	9	10	10	9	9	8
Average annual increase	(%)				(10.4)					(9.2)		
Average annual increase	(MW)				(7)					(10)		

Table 2.8. **(Continued)**

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Generation	(GWh)	699	773	846	930	1 025	1 125	1 240	1 361	1 498	1 650
Annual increase	(GWh)	55	74	73	84	95	100	115	121	137	152
Annual increase	(%)	8	10	9	10	10	10	10	10	10	10
Average annual increase	(%)	←		(9.4)		→	←		(10)		→
Losses	(%)	15	15	15	15	15	15	15	15	15	15
	(GWh)	105	116	127	140	154	169	186	204	225	248
Consumption	(GWh)	594	657	719	790	871	956	1 054	1 157	1 273	1 402
Annual increase	(GWh)	59	63	62	71	81	85	98	103	116	129
Annual increase	(%)	11	11	10	10	10	10	10	10	10	10
Average annual increase	(%)	←		(10.4)		→	←		(10)		→
Per capita	(kWh)	214	230	244	260	278	296	317	337	360	384
Load factor	(%)	60	60	60	60	60	60	60	60	60	60
Maximum demand	(MW)	133	147	161	177	195	214	236	259	285	314
Annual increase	(MW)	12	14	14	16	18	19	22	23	26	29
Annual increase	(%)	10	10	10	10	10	10	10	10	10	10
Average annual increase	(%)	←		(10)		→	←		(10)		→
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20
	(MW)	27	29	32	35	39	43	47	52	57	63
Capacity demand	(MW)	160	176	193	212	234	257	283	311	342	377
Annual increase	(MW)	14	17	17	19	20	23	26	28	31	35
Annual increase	(%)	10	10	10	10	10	10	10	10	10	10
Average annual increase	(%)	←		(10)		→	←		(10)		→
Average annual increase	(MW)	←		(17)		→	←		(24)		→

Source: Joint ECWA/UNIDO Industry Division.

Qatar (See table 2.9)

The forecast of peak loads in Qatar during 1977-1983 was prepared by the Ministry of Electricity and Water. It indicates a tremendous growth: from 250 MW in 1977 to 1,220 MW in 1983. The forecasted increasr in demand during that period consists of 600 MW for new factories, and about 50 MW per annum for normal consumption.

An attempt was made to construct table 2.9 based on the above forecast. However, that attempt was abandoned because the resulting per capita consumption sky-rocketed to fantastic levels, by Gulf States and world standards, of over 60,000 kWh by the year 2000. By comparision, the per capita consumption in Norway which is the highest in the world was 15,537 kWh[1/] in 1971 and 17,956 kWh[2/] in 1975. Strictly speaking, there is no valid reason to discard the given forecast because oil-rich developing countries like Qatar can well afford to invest in new industries.

Because it was preferred that the capacity demand projections be on the conservative side, it was decided to use the 50 MW per annum increase in load demand forecast for normal consumption, and to ignore the 600 MW forecast for new industries.

It is assumed that the load factor during the period 1980-1990 will be 49 per cent which is equal to the load factor up to 1976. It is assumed that losses will be 15 per cent.

During the period 1991-2000, it is assumed that the generation rate of increase will decrease substantially; at 4 per cent per annum, it is approximately equal to the projected population growth rate, indicating that a state of consumption saturation is being reached. It is assumed that the load factor will increase slightly to 50 per cent, and losses to decrease to 12 per cent.

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
60 MW	60 MW	42 MW	56 MW

Saudi Arabia (See table 2.10)

The available data on Saudi Arabia provides very little information on the future development of its power system. The basis for the projections shown in table 2.10 is a forecast of installed capacity in the years 1978, 1983 and 1988, which is believed to be extracted from a report prepared by a consultant for the Ministry of Industry and Electricity.

1/ World energy supplies 1971-1975, United Nations, New York 1977, Publication No.ST/ESA/STAT/SER.J/20.

2/ Ibid.

2.9 Estimated generation capacity demand, 1980-2000 Qatar

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	2000
Generation	(GWh)	1 717	1 932	2 146	2 361	2 575	2 790	3 005	3 219	3 434	3 649	3 863
Annual increase	(GWh)	215	215	214	215	214	215	215	214	215	215	214
Annual increase	(%)	14	13	11	10	9	8	8	7	7	6	6
Average annual increase	(%)	←			(10.2)		→	←		(6.8)		→
Losses	(%)	15	15	15	15	15	15	15	15	15	15	15
	(GWh)	258	290	322	354	386	419	451	483	515	547	579
Consumption	(GWh)	1 459	1 642	1 824	2 007	2 189	2 371	2 554	2 736	2 919	3 102	3 284
Annual increase	(GWh)	182	183	182	183	182	182	183	182	183	183	182
Annual increase	(%)	14	13	11	10	9	8	8	7	7	6	6
Average annual increase	(%)	←			(10.2)		→	←		(6.8)		→
Per capita	(kWh)	7 054	17 670	18 232	18 752	19 222	19 651	10 094	10 498	10 874	11 219	11 531
Load factor	(%)	49	49	49	49	49	49	49	49	49	49	49
Maximum demand	(MW)	400	450	500	550	600	650	700	750	800	850	900
Annual increase	(MW)	50	50	50	50	50	50	50	50	50	50	50
Annual increase	(%)	14	12	11	10	9	8	8	7	7	6	6
Average annual increase	(%)	←			(10)		→	←		(6.8)		→
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20	20
	(MW)	80	90	100	110	120	130	140	150	160	170	180
Capacity demand	(MW)	480	540	600	660	720	780	840	900	960	1 020	1 080
Annual increase	(MW)	60	60	60	60	60	60	60	60	60	60	60
Annual increase	(%)	14	12	11	10	9	8	8	7	7	6	6
Average annual increase	(MW)	←			(10)		→	←		(6.8)		→
Average annual increase	(MW)	←			(60)		→	←		(60)		→

Table 2.9. (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Generation	(GWh)	4 018	4 179	4 346	4 520	4 701	4 889	5 085	5 288	5 500	5 700
Annual increase	(GWh)	155	161	167	174	181	188	196	203	212	220
Annual increase	(%)	4	4	4	4	4	4	4	4	4	4
Average annual increase(%)		←		(4)		→	←		(4)		→
Losses	(%)	12	12	12	12	12	12	12	12	12	12
	(GWh)	482	501	522	542	564	587	610	635	660	686
Consumption	(GWh)	3 536	3 678	3 824	3 978	4 137	4 302	4 475	4 653	4 840	5 034
Annual increase	(GWh)	252	142	146	154	159	165	173	178	187	194
Annual increase	(%)	8	4	4	4	4	4	4	4	4	4
Average annual increase(%)		←		(4.8)		→	←		(4)		→
Per capita	(kWh)	11 996	12 056	12 111	12 165	12 240	12 221	12 226	12 244	12 253	12 248
Load factor	(%)	50	50	50	50	50	50	50	50	50	50
Maximum demand	(MW)	917	954	992	1 032	1 073	1 116	1 161	1 207	1 256	1 306
Annual increase	(MW)	17	37	38	40	41	43	45	46	49	50
Annual increase	(%)	2	4	4	4	4	4	4	4	4	4
Average annual increase(%)		←		(3.6)		→	←		(4)		→
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20
	(MW)	183	191	198	206	215	223	232	241	251	261
Capacity demand	(MW)	1 100	1 145	1 190	1 238	1 288	1 339	1 393	1 448	1 507	1 567
Annual increase	(MW)	20	45	45	48	50	49	54	56	59	60
Annual increase	(%)	2	4	4	4	4	4	4	4	4	4
Average annual increase(%)		←		(3.6)		→	←		(4)		→
Average annual increase(MW)		←		(42)		→	←		(56)		→

Source: Joint ECWA/UNIDO Industry Division.

Table 2.10. Estimated generation capacity demand, 1980-2000 Saudi Arabia

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	2000
Generation	(GWh)	7 753	9 229	10 981	13 066	16 464	20 752	26 162	32 973	41 575	44 632	47 917
Annual increase	(GWh)	1 236	1 476	1 752	2 085	3 398	4 288	5 410	6 811	8 602	3 057	3 285
Annual increase	(%)	19	19	19	19	26	26	26	26	26	7	7
Average annual increase(%)		←			(21.8)		→	←		(18.4)		→
Losses	(%)	15	15	15	15	15	15	15	15	15	15	15
	(GWh)	1 163	1 384	1 647	1 960	2 470	3 113	3 924	4 946	6 236	6 695	7 188
Consumption	(GWh)	6 590	7 845	9 334	11 106	13 994	17 639	22 238	28 027	35 339	37 937	40 729
Annual increase	(GWh)	1 051	1 255	1 489	1 772	2 888	3 645	3 599	5 789	7 312	2 598	2 792
Annual increase	(%)	19	19	19	19	26	26	26	26	26	7	7
Average annual increase(%)		←			(21.8)		→	←		(18.4)		→
Per capita	(kWh)	632	730	843	973	1 189	1 454	1 778	2 175	2 661	2 773	2 890
Load factor	(%)	50	50	50	50	50	50	50	50	50	50	50
Maximum demand	(MW)	1 770	2 107	2 507	2 983	3 759	4 738	5 973	7 528	9 492	10 190	19 940
Annual increase	(MW)	282	337	400	476	776	979	1 235	1 555	1 964	698	750
Annual increase	(%)	19	19	19	19	26	26	26	26	26	7	7
Average annual increase(%)		←			(21.8)		→	←		(18.4)		→
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20	20
	(MW)	354	421	501	597	752	948	1 195	1 506	1 898	2 038	2 188
Capacity demand	(MW)	2 124	2 528	3 008	3 579	4 511	5 686	7 167	9 034	11 390	12 228	13 128
Annual increase	(MW)	339	404	480	571	932	1 175	1 481	1 867	2 356	838	900
Annual increase	(%)	19	19	19	19	26	26	26	26	26	7	7
Average annual increase(%)		←			(21.8)		→	←		(18.4)		→
Average annual increase(MW)		←			(721)		→	←		(1 488)		→

Table 2.10. (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Generation	(GWh)	51 447	55 232	59 296	63 659	68 346	73 378	78 779	84 573	90 802	97 486
Annual increase	(GWh)	3 530	3 785	4 064	4 363	4 687	5 032	5 401	5 794	6 229	6 684
Annual increase	(%)	7	7	7	7	7	7	7	7	7	7
Average annual increase	(%)			(7)					(7)		
Losses	(%)	15	15	15	15	15	15	15	15	15	15
	(GWh)	7 717	8 285	8 894	9 549	10 252	11 007	11 817	12 686	13 620	14 623
Construction	(GWh)	43 730	46 947	50 402	54 110	58 094	62 371	66 962	71 887	77 182	82 863
Annual increase	(GWh)	3 001	3 217	3 455	3 708	3 984	4 277	4 591	4 925	5 295	5 681
Annual increase	(%)	7	7	7	7	7	7	7	7	7	7
Average annual increase	(%)			(7)					(7)		
Per capita	(kWh)	3 012	3 141	3 276	3 418	3 567	3 725	3 892	4 069	4 256	4 455
Load factor	(%)	50	50	50	50	50	50	50	50	50	50
Maximum demand	(MW)	11 746	12 610	13 538	14 534	15 604	16 753	17 986	19 309	20 731	22 257
Annual increase	(MW)	806	864	928	996	1 070	1 149	1 233	1 323	1 422	1 526
Annual increase	(%)	7	7	7	7	7	7	7	7	7	7
Average annual increase	(%)			(7)					(7)		
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20
	(MW)	2 349	2 522	2 708	2 907	3 121	3 351	3 597	3 862	4 146	4 451
Capacity demand	(MW)	14 095	15 132	16 246	17 441	18 725	20 103	21 583	23 171	24 877	26 708
Annual increase	(MW)	967	1 037	1 114	1 195	1 284	1 378	1 480	1 588	1 706	1 831
Annual increase	(%)	7	7	7	7	7	7	7	7	7	7
Average annual increase	(%)			(7)					(7)		
Average annual increase	(MW)			(1 119)					(1 597)		

Source: ECWA, Joint ECWA/UNIDO Industry Division.

It is assumed that the load factor and losses will be 50 per cent and 15 per cent respectively during the entire projection period. The assumed load factor is equivalent to load factors in the Gulf region. The relatively high losses are due to the poor state of the country's networks1/. Maximum demand is assumed to decrease to an annual rate of 7 per cent from 1988 to 2000 to enable the expected power projects to be consolidated.

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
721 MW	1,488 MW	1,119 MW	1,597 MW

Syria (See table 2.11)

The forecast of maximum demand, generation, load factor, losses and consumption in Syria during 1977-1990 was prepared by the AFESD.

For the period 1991-2000, we have assumed that the growth rate of maximum demand will be slower than the average rate during 1980-1990. This is in line with the trend forecast for the end of 1980-1990 period and indicates, according to Syrian officials, a shift in government priorities: less investment in industry, and more investment in other sectors of the economy.

It is assumed that the load factor during 1991-2000 will be 56 per cent. The slight increase over the previous period indicates the expected integration of isolated loads and "captive plants" mainly in the manufacturing industries, into the national network.

It is assumed that losses during 1991-2000 will be 15 per cent. Although this indicates improvement over the previous period, it is still high compared to Syria's neighbours: 12 per cent in Jordan, 10 per cent in Lebanon and Iraq. We feel that our assumption and that of the AFESD regarding the previous period are conservative. The implication is that the actual per capita consumption is likely to be higher than that shown in table 2.11.

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
208 MW	276 MW	430 MW	680 MW

1/ It is most probable that Saudi Arabia will have three networks because of its huge area and population distribution.

Table 2.11. Estimated generation capacity demand, 1980-2000 Syria

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Generation	(GWh)	4 025	4 701	5 458	6 293	7 211	8 207	9 274	10 413	11 613	12 862	14 148
Annual increase	(GWh)	601	676	757	835	918	996	1 067	1 139	1 200	1 249	1 286
Annual increase	(%)	18	17	16	15	15	14	13	12	12	11	10
Average annual increase	(%)	←			(15.4)		→	←		(11.6)		→
Losses	(%)	18	18	18	18	18	18	18	18	18	18	18
	(GWh)	745	847	982	1 133	1 298	1 477	1 669	1 874	2 090	2 316	2 547
Consumption	(GWh)	3 280	3 854	4 476	5 160	5 913	6 730	7 605	8 539	9 523	10 546	11 601
Annual increase	(GWh)	507	574	622	684	753	817	875	934	984	1 023	1 055
Annual increase	(%)	18	18	16	15	15	14	13	12	12	11	10
Average annual increase	(%)	←			(15.6)		→	←		(11.6)		→
Per capita	(kWh)	378	430	483	539	599	660	721	784	847	908	967
Load factor	(%)	55	55	55	55	55	55	55	55	55	55	55
Maximum demand	(MW)	835	976	1 133	1 306	1 476	1 703	1 925	2 161	2 410	2 593	2 853
Annual increase	(MW)	124	141	157	173	170	227	222	236	249	183	260
Annual increase	(%)	17	17	16	15	13	15	13	12	12	8	10
Average annual increase	(%)	←			(15.2)		→	←		(11)		→
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20	20
	(MW)	167	195	227	261	295	341	385	432	482	519	571
Capacity demand	(MW)	1 002	1 171	1 360	1 567	1 771	2 044	2 310	2 593	2 892	3 112	3 424
Annual increase	(MW)	149	169	189	207	204	273	266	283	299	220	312
Annual increase	(%)	17	17	16	15	13	15	13	12	12	8	10
Average annual increase	(%)	←			(15.2)		→	←		(11)		→
Average annual increase	(MW)	←			(208)		→	←		(276)		→

Table 2.11. (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Generation	(GWh)	15 563	17 119	18 831	20 714	22 785	25 064	27 570	30 327	33 360	36 696
Annual increase	(GWh)	1 415	1 556	1 712	1 883	2 071	2 279	2 506	2 757	3 033	3 336
Annual increase	(%)	10	10	10	10	10	10	10	10	10	10
Average annual increase	(%)	←		(10)		→	←		(10)		→
Losses	(%)	15	15	15	15	15	15	15	15	15	15
	(GWh)	2 334	2 568	2 825	3 107	3 418	3 760	4 136	4 549	5 004	5 504
Consumption	(GWh)	13 229	14 551	16 006	17 607	19 367	21 304	23 434	25 778	28 356	31 192
Annual increase	(GWh)	1 628	1 322	1 455	1 601	1 760	1 937	2 130	2 344	2 578	2 836
Annual increase	(%)	14	10	10	10	10	10	10	10	10	10
Average annual increase	(%)	←		(10.8)		→	←		(10)		→
Per capita	(kWh)	1 068	1 137	1 211	1 289	1 373	1 462	1 557	1 658	1 765	1 880
Load factor	(%)	56	56	56	56	56	56	56	56	56	56
Maximum demand	(MW)	3 172	3 490	3 839	4 223	4 645	5 109	5 620	6 182	6 800	7 480
Annual increase	(MW)	319	318	349	384	422	464	511	562	618	680
Annual increase	(%)	11	10	10	10	10	10	10	10	10	10
Average annual increase	(%)	←		(10.2)		→	←		(10)		→
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20
	(MW)	634	698	768	845	929	1 022	1 124	1 236	1 360	1 496
Capacity demand	(MW)	3 806	4 188	4 607	5 068	5 574	6 131	6 744	7 418	8 160	8 976
Annual increase	(MW)	382	382	419	461	506	557	613	674	742	816
Annual increase	(%)	11	10	10	10	10	10	10	10	10	10
Average annual increase	(%)	←		(10.2)		→	←		(10)		→
Average annual increase	(MW)	←		(430)		→	←		(680)		→

Source: Joint ECWA/UNIDO Industry Division

United Arab Emirates (UAE) (See table 2.12)

Very little useful data is available on the UAE. The projections made in this study are based on a forecast made in 1975 by the Ministry of Electricity and Water. The forecast extend only to 1980; consequently very many assumptions have had to be made.

The growth rate of maximum demand is assumed to drop from about 30 per cent during 1976-1980 to 10 per cent during 1981-1990. During 1991-2000, it is assumed that the average growth of maximum demand will be 6 per cent per annum which is in harmony with the projected rate of population growth (table 2.18). It is assumed that the load factor will be 49 per cent during 1981-1990 and 50 per cent during 1991-2000. Those values are similar to those in the small Gulf countries. It is assumed that losses will be 15 per cent during 1981-1990 and 12 per cent during 1991-2000.

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
215 MW	346 MW	309 MW	413 MW

Yemen Arab Republic (YAR) (See table 2.13)

The available data give three forecasts of maximum demand, generation, and load factor. The first forecast was made by the Yemeni authorities. The second was made by a British consulting firm, Kennedy and Donkin, and the third by the AFESD. We dismissed the first forecast because it seems overly ambitious. The other two are very similar to one another. However, because the AFESD forecast covers a longer period, up to 1990, it was chosen for this study.

During 1991-2000 it was assumed that the growth rate of maximum demand will decline to 15 per cent. This is consistent with the trend towards the end of the previous period, and indicates stabilization in the development of the power system. The load factor will increase slightly to 56 per cent during this period.

It is assumed that losses will be 21 per cent during 1980-1990. This is equal to the 1970-1977 loss rate which was rather high. After 1990, the loss rate will probably decrease, reaching 15 per cent towards the end of the projection period.

The per capita consumption in the year 2000 is expected to be 415 kWh, which will make this power system one of the least developed in the region; only the power system in the PDRY will be less developed.

Table 2.12. Estimated generation capacity demand, 1980-2000
United Arab Emirates

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Generation	(GWh)	6 297	6 928	7 619	8 383	9 220	10 143	11 156	12 272	13 500	14 847	16 333
Annual increase	(GWh)	1 537	631	691	764	837	923	1 013	1 116	1 228	1 347	1 486
Annual increase	(%)	32	10	10	10	10	10	10	10	10	10	10
Average annual increase	(%)		←		(10)		→	←		(10)		→
Losses	(%)	15	15	15	15	15	15	15	15	15	15	15
	(GWh)	945	1 039	1 143	1 257	1 383	1 521	1 673	1 841	2 025	2 227	2 450
Consumption	(GWh)	5 352	5 889	6 476	7 126	7 837	8 622	9 483	10 431	11 475	12 620	13 883
Annual increase	(GWh)	1 306	537	587	650	711	785	861	948	1 044	1 145	1 263
Annual increase	(%)	32	10	10	10	10	10	10	10	10	10	10
Average annual increase	(%)		←		(10)		→	←		(10)		→
per capita	(kWh)	6 835	6 994	7 116	7 324	7 492	7 671	8 050	8 453	8 868	9 307	9 770
Load factor	(%)	49	49	49	49	49	49	49	49	49	49	49
Maximum demand	(MW)	1 467	1 614	1 775	1 953	2 148	2 363	2 599	2 859	3 145	3 459	3 805
Annual increase	(MW)	358	147	161	178	195	215	236	260	286	314	346
Annual increase	(%)	32	10	10	10	10	10	10	10	10	10	10
Average annual increase	(%)		←		(10)		→	←		(10)		→
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20	20
	(MW)	293	323	355	391	430	473	520	572	629	692	761
Capacity demand	(MW)	1 760	1 937	2 130	2 344	2 578	2 836	3 119	3 430	3 774	4 151	4 566
Annual increase	(MW)	429	177	193	214	234	258	283	311	344	377	415
Annual increase	(%)	32	10	10	10	10	10	10	10	10	10	10
Average annual increase	(%)		←		(10)		→	←		(10)		→
Average annual increase	(MW)		←		(215)		→	←		(346)		→

Table 2.12. (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Generation	(GWh)	17 665	18 725	19 850	21 042	22 303	23 639	25 058	26 565	28 155	29 845
Annual increase	(GWh)	1 332	1 060	1 125	1 192	1 261	1 336	1 419	1 507	1 590	1 690
Annual increase	(%)	8	6	6	6	6	6	6	6	6	6
Average annual increase	(%)			(6.4)					(6)		
Losses	(%)	12	12	12	12	12	12	12	12	12	12
	(GWh)	2 120	2 247	2 382	2 525	2 676	2 837	3 007	3 188	3 379	3 581
Consumption	(GWh)	15 545	16 478	17 468	18 517	19 627	20 802	22 051	23 377	24 776	26 264
Annual increase	(GWh)	1 662	933	990	1 049	1 110	1 175	1 249	1 326	1 399	1 488
Annual increase	(%)	12	6	6	6	6	6	6	6	6	6
Average annual increase	(%)			(7.2)					(6)		
Per capita	(kWh)	10 532	10 742	10 959	11 182	11 404	11 654	11 913	12 182	12 450	12 715
Load factor	(%)	50	50	50	50	50	50	50	50	50	50
Maximum demand	(MW)	4 033	4 275	4 532	4 804	5 092	5 397	5 721	6 065	6 428	6 814
Annual increase	(MW)	228	242	257	272	288	305	324	344	363	386
Annual increase	(%)	6	6	6	6	6	6	6	6	6	6
Average annual increase	(%)			(6)					(6)		
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20
	(MW)	807	855	906	961	1 018	1 079	1 144	1 213	1 286	1 363
Capacity demand	(MW)	4 840	5 130	5 438	5 765	6 110	6 476	6 865	7 278	7 714	8 177
Annual increase	(MW)	274	290	308	327	345	366	389	413	436	463
Annual increase	(%)	6	6	6	6	6	6	6	6	6	6
Average annual increase	(%)			(6)					(6)		
Average annual increase	(MW)			(309)					(413)		

Source: Joint ECWA/UNIDO Industry Division

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
26 MW	43 MW	83 MW	167 MW

ECWA region (See table 2.14)

The results of tables 2.1 to 2.13 were combined to derive the generation capacity demand for the whole region as shown in table 2.14.

The projected average annual increase in capacity demand is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
2,527 MW	4,578 MW	4,836 MW	7,383 MW

Assuming a depreciation rate of 4 per cent per annum, corresponding to a useful plant life of 25 years which is applicable to thermal generating plants, the projected average annual increase in installed capacity for each country was computed as shown in table 2.16. For the region as a whole, it is projected to be:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
2,628 MW	4,763 MW	5,029 MW	7,679 MW

An examination of tables 2.1 to 2.14 will indicate the disparity in per capita consumption of electricity among the countries of the ECWA region. The small Gulf States have and will continue to have the highest per capita rates. The disparity between those States and other countries in the region will continue to be very great.

Even with the significant increase in generation capacity projected for the ECWA countries, most people in the region, even in the year 2000, will consume less electricity than their counterparts in many areas of the world consumed in 1975. The above observations are set out in table 2.15.

Another set of projections of capacity demand, more optimistic than the previous ones, was developed by taking into account certain probable factors as stated below. These projections were made up to the year 1990 only because it was thought that extending the projection period beyond 1990 would not yield more precise results than those obtained previously due to the uncertainties and possible unforeseen development which might take place by then.

Table 2.13. Estimated generation capacity demand, 1980-2000
Yemen Arab Republic

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Generation	(GWh)	280	375	464	536	648	778	924	1 087	1 268	1 466	1 683
Annual increase	(GWh)	114	95	89	72	112	130	146	163	181	198	217
Annual increase	(%)	69	34	24	16	21	20	19	18	17	16	15
Average annual increase	(%)		←		(23)		→	←		(17)		→
Losses	(%)	21	21	21	21	21	21	21	21	21	21	21
	(GWh)	59	79	97	113	136	163	194	228	266	308	353
Consumption	(GWh)	221	296	367	423	512	615	730	859	1 002	1 158	1 330
Annual increase	(GWh)	90	75	71	56	89	103	115	129	143	156	172
Annual increase	(%)	69	34	24	16	21	20	19	18	17	16	15
Average annual increase	(%)		←		(23)		→	←		(17)		→
Per capita	(kWh)	28	37	44	50	58	68	78	90	102	114	127
Load factor	(%)	53	54	54	53	53	53	54	54	55	55	56
Maximum demand	(MWh)	61	79	98	116	140	168	197	230	265	303	346
Annual increase	(MW)	23	18	19	18	24	28	29	33	35	38	43
Annual increase	(%)	61	30	24	18	21	20	17	17	15	14	14
Average annual increase	(%)		←		(22.6)		→	←		(15.4)		→
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20	20
	(MW)	12	16	20	23	28	34	39	46	53	61	69
Capacity demand	(MW)	73	95	118	139	168	202	236	276	318	364	415
Annual increase	(MW)	27	22	23	21	29	34	34	40	42	46	51
Annual increase	(%)	60	30	24	18	21	20	18	17	15	14	14
Average annual increase	(%)		←		(22.6)		→	←		(15.6)		→
Average annual increase	(MW)		←		(26)		→	←		(43)		→

Table 2.13. (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Generation	(GWh)	1 935	2 225	2 559	2 943	3 384	3 892	4 476	5 147	5 919	6 807
Annual increase	(GWh)	252	290	334	384	441	508	584	671	772	888
Annual increase	(%)	15	15	15	15	15	15	15	15	15	15
Average annual increase	(%)			(15)					(15)		
Losses	(%)	18	18	18	18	18	15	15	15	15	15
	(GWh)	348	401	461	530	609	584	671	772	888	1 021
Consumption	(GWh)	1 587	1 824	2 098	2 413	2 775	3 308	3 805	4 375	5 031	5 786
Annual increase	(GWh)	257	237	274	315	362	533	497	570	656	755
Annual increase	(%)	19	15	15	15	15	19	15	15	15	15
Average annual increase	(%)			(15.8)					(15.8)		
Per capita	(kWh)	147	165	184	206	230	266	298	333	372	415
Load factor	(%)	56	56	56	56	56	56	56	56	56	56
Maximum demand	(MW)	394	454	522	600	690	793	912	1 049	1 206	1 387
Annual increase	(MW)	48	60	68	78	90	103	119	137	157	181
Annual increase	(%)	14	15	15	15	15	15	15	15	15	15
Average annual increase	(%)			(14.8)					(15)		
Capacity reserve	(%)	20	20	20	20	20	20	20	20	20	20
	(MW)	79	91	104	120	138	159	182	210	241	277
Capacity demand	(MW)	473	545	626	720	828	952	1 094	1 259	1 447	1 664
Annual increase	(MW)	58	72	81	94	108	124	142	165	188	217
Annual increase	(%)	14	15	15	15	15	15	15	15	15	15
Average annual increase	(%)			(14.8)					(15)		
Average annual increase	(MW)			(83)					(167)		

Source: Joint ECWA/UNIDO Industry Division.

Table 2.14. Estimated generation capacity demand, 1980-2000
ECWA region

		1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Generation	(GWh)	64 299	71 695	80 103	89 183	100 520	113 398	128 909	146 982	168 015	184 447	202 512
Annual increase	(GWh)		7 396	8 408	9 080	11 337	12 878	15 511	18 073	21 033	16 432	18 065
Annual increase	(%)		12	12	11	13	13	14	14	14	10	10
Average annual increase	(%)				(12.2)					(12.4)		
Losses	(GWh)	9 634	10 709	11 935	13 266	14 913	16 813	19 098	21 739	24 831	27 234	29 858
	%		15	15	15	15	15	15	15	15	15	15
Consumption	(GWh)	54 665	60 984	68 168	75 917	85 607	96 585	109 811	125 243	143 184	157 213	172 654
Annual increase	(GWh)		6 332	7 184	7 749	9 690	10 978	13 226	15 432	17 941	14 029	15 441
Annual increase	(%)		12	12	11	13	13	14	14	14	10	10
Average annual increase	(%)				(12.2)					(12.4)		
Per capita	(kWh)		637	691	749	821	900	996	1 104	1 229	1 313	1 403
Maximum demand	(MW)	12 969	14 522	16 249	18 207	20 611	23 430	26 778	30 696	35 251	38 741	42 613
Annual increase	(MW)		1 553	1 727	1 958	2 404	2 819	3 384	3 918	4 555	3 490	3 872
Annual increase	(%)		12	12	12	13	14	14	15	15	10	10
Average annual increase	(%)				(12.6)					(12.8)		
Capacity reserve	(MW)	2 664	2 963	3 297	3 827	4 291	4 839	5 489	6 251	7 137	7 808	8 554
	(%)		20	20	21	21	21	21	21	21	21	21
Capacity demand	(MW)	15 633	17 485	19 546	22 034	24 902	28 269	32 267	36 947	42 388	46 549	51 167
Annual increase	(MW)		1 852	2 061	2 488	2 868	3 367	3 998	4 680	5 441	4 161	4 618
Annual increase	(%)		12	12	13	13	14	14	15	15	10	10
Annual average increase	(%)				(12.8)					(12.8)		
Average annual increase	(MW)				(2 527)					(4 578)		
Installed capacity	(MW)	16 258	18 184	20 328	22 915	25 898	29 400	33 558	38 425	44 084	48 411	53 214
Annual increase	(MW)		1 926	2 144	2 587	2 983	3 502	4 158	4 867	5 659	4 327	4 803
Annual increase	(%)		12	12	13	13	14	14	15	15	10	10
Average annual increase	(%)				(12.8)					(12.8)		
Average annual increase	(MW)				(2 628)					(4 763)		
Per one thousand people	(kW)		190	206	226	248	274	304	339	378	404	432

Table 2.14. (Continued)

		1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
<u>Generation</u>	(GWH)	221 489	239 445	259 044	280 799	303 804	328 882	356 189	386 033	418 668	454 413
Annual increase	(GWh)	18 977	17 956	19 599	21 755	23 005	25 078	27 307	29 844	32 635	35 745
Annual increase	(%)	9	8	8	8	8	8	8	8	8	9
Average annual increase	(%)	←		(8.2)		→	←		(8.2)		→
<u>Losses</u>	(GWh)	29 301	31 618	34 140	36 917	39 869	42 984	46 540	50 201	54 316	58 810
	(%)	13	13	13	13	13	13	13	13	13	13
<u>Consumption</u>	(GWh)	192 188	207 827	224 904	243 882	263 935	285 898	309 649	335 832	364 352	395 603
Annual increase	(GWh)	19 543	15 639	17 077	18 978	20 053	21 963	23 751	22 423	28 520	31 251
Annual increase	(%)	11	8	8	8	8	8	8	7	7	9
Average annual increase	(%)	←		(8.6)		→	←		(7.8)		→
Per capita	(kWh)	1 520	1 602	1 688	1 784	1 882	1 987	2 099	2 221	2 352	2 493
<u>Maximum demand</u>	(MW)	46 037	49 762	53 817	58 181	62 925	68 082	73 677	79 864	86 587	93 954
Annual increase	(MW)	3 424	3 725	4 055	4 364	4 744	5 157	5 595	6 187	6 723	7 367
Annual increase	(%)	8	8	8	8	8	8	8	8	8	8
Average annual increase	(%)	←		(8)		→	←		(8)		→
<u>Capacity reserve</u>	(MW)	9 208	9 917	10 688	11 519	12 421	13 402	14 464	15 639	16 913	18 309
	(%)	20	20	20	20	20	20	20	20	20	20
<u>Capacity demand</u>	(MW)	55 245	59 679	64 505	69 700	75 346	81 484	88 141	95 503	103 500	112 263
Annual increase	(MW)	4 078	4 434	4 826	5 195	5 646	6 138	6 657	7 362	7 997	8 763
Annual increase	(%)	8	8	8	8	8	8	8	8	8	8
Average annual increase	(%)	←		(8)		→	←		(8)		→
Average annual increase	(MW)	←		(4 836)		→	←		(7 383)		→
<u>Installed capacity</u>	(MW)	57 454	62 066	67 085	72 488	78 360	84 743	91 666	99 323	107 640	116 754
Annual increase	(MW)	4 241	4 612	5 019	5 403	5 872	6 383	6 924	7 657	8 317	9 114
Annual increase	(%)	8	8	8	8	8	8	8	8	8	8
Average annual increase	(%)	←		(8)		→	←		(8)		→
Average annual increase	(MW)	←		(5 029)		→	←		(7 679)		→
Per one thousand people	(kW)	455	478	504	530	559	589	621	657	695	736

<u>Source</u>: Joint ECWA/UNIDO Industry Division.

Bahrain: The per capita consumption could be higher than given in the previous projections and more in line with per capita consumption in other small Gulf States. This would result in capacity demand projections that are 55 per cent and 10 per cent higher than the previous projections in the years 1985 and 1990 respectively.

Egypt: The load factor could be lower, and the per capita consumption higher around 1985, than given in the previous projections. This would result in an increase in capacity demand of about 25 per cent over the previous projections. By 1990 the two sets of projections could become very close.

Iraq: The load factor could be lower and the per capita consumption higher than given in the previous projections. The combined effect of these factors would result in 50 per cent and 33 per cent more capacity demand in the years 1985 and 1990 respectively than given in the previous projections.

Qatar: The load factor could be lower and the generated MWs greater (due to possible industrial loads) than given in the previous projections. These factors would result in 50 per cent more capacity demand in the period 1985-1990.

Saudi Arabia: The per capita consumption especially around 1985 could be much greater than given in the previous projections which are very modest in light of the country's resources. The load factor could be lower than projected previously. Capacity demand may be 150 per cent and 33 per cent more than given in the previous projections in the years 1985 and 1990 respectively.

U A E: The load factor could be lower and the per capita consumption higher than given in the previous projections. These factors would give rise to a 50 per cent and 30 per cent more capacity demand in the years 1985 and 1990 respectively.

The above considerations are incorporated in an "Optimistic" set of projections as shown below:

"Optimistic" Capacity Demand Projections (MW)

Country	1985	1990
Bahrain	1 300	1 590
Egypt	7 250	(10 060)1/
Iraq	5 550	8 600
Jordan	(505)	(812)
Kuwait	(4 200)	(6 600)
Lebanon	(1 364)	(2 746)
Oman	(220)	(287)
PDRY	(96)	(145)
Qatar	1 200	1 600
Saudi Arabia	14 000	17 500
Syria	(2 044)	(3 424)
U A E	4 250	5 950
Y A R	(202)	(415)
ECWA region	42 181	59 729

According to the optimistic projections, capacity demand in the ECWA region as a whole would be about 50 per cent and 17 per cent more than the earlier pessimistic projections indicated for the years 1985 and 1990 respectively. The single major factor accounting for the discrepancy between the two sets of projections is the scope and intensity of the electric power programme in Saudi Arabia about which little information is available at present.

It should be noted that all subsequent analyses and results in this report are based on the previous "Pessimistic" projections (table 2.1 to 2.14) because it was felt that the results of the pre-feasibility studies would be more plausible by using the conservative demand projections.

1/ The capacity demand figures in parentheses are the same ones given in the previous "Pessimistic" projections.

Table 2.15. Per capita consumption (kWh) in ECWA region and in other countries

Country	Actual 1975	Projected 1980	1985	1990	1995	2000
Bahrain	2 305	4 840	7 294	10 774	12 947	14 431
Egypt	280	414	524	758	947	1 147
Iraq	364	533	847	1 294	1 954	2 799
Jordan	164	432	793	1 088	1 516	2 099
Kuwait	5 174	5 706	7 152	9 195	11 286	12 634
Lebanon	645	719	1 232	2 126	3 841	6 664
Oman	399	532	646	722	798	888
PDRY	107	107	152	199	278	384
Qatar	1 087	7 054	19 651	11 531	12 240	12 248
Saudi Arabia	277	1 632	1 454	2 890	3 567	4 455
Syria	227	378	660	967	1 373	1 880
UAE	2 252	6 835	7 671	9 770	11 404	12 715
YAR	7	28	68	127	230	415
ECWA region		588	900	1 403	1 882	2 493
World	1 631					
Developed	5 731					
Developing	281					
Africa	324					
Australia	5 476					
W. Europe	3 928					
USA	9 396					
Canada	11 617					

Source: Joint ECWA/UNIDO Industry Division for projections; and world energy supplies 1971-1975, United Nations, New York 1977, Publication No. ST/ESA/STAT/SER/J/20 for actual 1975 values.

Table 2.16. Projected growth of installed generation capacity (MW), 1980-2000

Country	Average annual increase			
	1981-1985	1986-1990	1991-1995	1996-2000
Bahrain	76	127	83	106
Egypt	387	887	753	997
Iraq	355	574	937	1 519
Jordan	52	63	106	167
Kuwait	325	499	477	646
Lebanon	143	287	577	1 170
Oman	14	14	16	20
PDRY	7	10	18	25
Qatar	62	62	44	58
Saudi Arabia	750	1 548	1 164	1 660
Syria	216	287	447	707
UAE	224	360	321	430
YAR	27	45	86	174
ECWA region	2 628	4 763	5 029	7 679

Source: Joint ECWA/UNIDO Industry Division

Table 2.17. Recent electricity statistics in ECWA region

Country		Generation GWh	Losses GWh	Consumption GWh	Maximum demand MW	L F per cent
Bahrain	1976	682	56	626	171	45.5
Egypt	1975	9 793	1 485	8 308	1 770	...
Iraq	1973	2 583	209	2 374	525	...
Jordan	1976	503	65	438	97	58.9
Kuwait	1975	4 653	...	...	1 120	47.4
Lebanon	1973	1 788	...	...	...	...
Oman		...	...	...	...	...
PDRY	1975	144	30	114	24	...
Qatar	1976	801	...	...	180	...
Saudi Arabia	1974	1 256	...	...	...	...
Syria	1976	1 459	200	1 259	327	50.9
UAE	1975	1 259	...	...	374	...
YAR	1976	62	16	46	16	...

Source: Joint ECWA/UNIDO Industry Division

Table 2.18 Population projections in ECWA region (In thousands), 1980-2000

Country	Actual 1975	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Bahrain	251	294	303	313	323	334	344	355	367	378	390	403
Egypt	37 543	42 144	43 118	44 110	45 121	46 148	47 191	48 251	49 326	50 416	51 521	52 640
Iraq	11 061	13 145	13 605	14 080	14 569	15 068	15 578	16 098	16 627	17 166	17 716	18 277
Jordan	1 820	2 141	2 211	2 284	2 360	2 438	2 518	2 601	2 687	2 776	2 867	2 962
Kuwait	1 085	1 439	1 512	1 586	1 662	1 738	1 816	1 895	1 976	2 058	2 143	2 229
Lebanon	2 869	3 360	3 471	3 587	3 706	3 829	3 956	4 086	4 220	4 356	4 496	4 637
Oman	766	898	927	957	988	1 020	1 053	1 086	1 121	1 156	1 193	1 231
Qatar	170	207	214	222	229	238	246	253	261	269	277	285
Saudi Arabia	8 966	10 423	10 744	11 076	11 417	11 770	12 132	12 505	12 887	13 279	13 682	14 094
Syria	7 259	8 536	8 825	9 125	9 435	9 754	10 081	10 415	10 755	11 103	11 459	11 823
UAE	558	783	842	905	973	1 046	1 124	1 178	1 234	1 294	1 356	1 421
YAR	6 668	7 741	7 978	8 222	8 474	8 733	9 000	9 275	9 556	9 845	10 141	10 445
PDRY	1 660	1 928	1 987	2 047	2 110	2 175	2 241	2 309	2 380	2 452	2 525	2 601
ECWA region	80 676	93 039	95 737	98 514	101 367	104 291	107 280	110 307	113 397	116 548	119 766	123 048

Country	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Bahrain	415	427	440	454	468	481	494	508	522	536
Egypt	53 772	54 918	56 077	57 250	58 438	59 639	60 855	62 085	63 329	64 588
Iraq	18 849	19 433	20 026	20 629	21 242	21 863	22 494	23 134	23 784	24 445
Jordan	3 060	3 160	3 265	3 373	3 484	3 599	3 718	3 840	3 967	4 098
Kuwait	2 318	2 408	2 501	2 595	2 690	2 787	2 885	2 983	3 083	3 183
Lebanon	4 782	4 928	5 075	5 224	5 373	5 523	5 673	5 823	5 971	6 118
Oman	1 268	1 306	1 346	1 387	1 429	1 469	1 509	1 551	1 595	1 639
Qatar	295	305	316	327	338	352	366	380	395	411
Saudi Arabia	14 517	14 948	15 387	15 833	16 285	16 742	17 203	17 667	18 133	18 600
Syria	12 194	12 573	12 959	13 351	13 750	14 153	14 563	14 917	15 398	15 824
UAE	1 476	1 534	1 594	1 656	1 721	1 785	1 851	1 919	1 990	2 064
YAR	10 755	11 072	11 394	11 722	12 054	12 390	12 728	13 069	13 410	13 753
PDRY	2 678	2 757	2 837	2 919	3 002	3 085	3 169	3 254	3 339	3 425
ECWA region	126 379	129 769	133 217	136 720	140 274	143 868	147 508	151 190	154 916	158 684

Source: Joint ECWA/UNIDO Industry Division.

2.3 Transformation capacity

Projections of the aggregate transformation capacity are based on two parameters: the generation capacity demand and the highest transmission voltage in the network. From the former, the step-up transformation capacity is obtained by dividing the generation capacity by the power factor (PF) which is assumed in this study to be 80 per cent.

From the highest transmission voltage in the network it is possible to estimate the number of step-down transformations as shown in table 2.19.

Table 2.19 Estimated number of step-down transformations

Country	Projected highest transmission voltage in kV	Number of step-down transformations
Bahrain	66	2
Egypt	500	4
Iraq	400	4
Jordan	230	3
Kuwait	300	3
Lebanon	150	3
Oman	33	2
PDRY	132	2
Qatar	132	2
Saudi Arabia	400	4
Syria	230	3
U A E	220	3
Y A R	132	2

Source: Joint ECWA/UNIDO Industry Division

The total number of transformations equals the number of the step-down transformations plus one step-up transformation. The transformation capacity is obtained by multiplying that number by the step-up transformation capacity.

The results of the above calculation are set out in tables 2.20 and 2.21. It indicates that the projected average annual increase in transformation capacity in the region is:

1981 - 1985	1986 - 1990	1991 - 1995	1996 - 2000
14,196 MVA	26,206 MVA	27,312 MVA	41,451 MVA

It should be mentioned in this context that the projected capacities are probably underestimated. The reasons are:

(a) The values of the highest transmission voltages given in table 2.19 are more applicable to the near future. It is reasonable to envisage that higher line voltages will be adopted in the next decade as national networks become integrated;

(b) All transformers in the network are assumed to be fully loaded. In practice this is not the case; a certain percentage of the transformers capacity is left as reserve;

(c) Stand-by transformers are not taken into account in the projections. As a general rule, some transformers are designated for emergency use in case other transformers fail to function properly;

(d) The transformers' depreciation rate is not account in the computations. The normal life span of a transformer is about 25 years.

2.4 Turbines and generators

An attempt is made in this section to project the number of generating units which will be needed during the projection period. The projections are based on the following:

(a) The projected increase in generation capacity demand (section 2.2);

(b) The projected types of generation and sizes of the generating units (chapter 1).

The results are set out in table 2.22. It indicates that during the next decade[1/] the number of required generating units will be as follows:

Types of generation	1991-1995	1996-2000
Steam	18 x 100 MW	2 x 100 MW
	28 x 150 MW	7 x 150 MW
	38 x 300 MW	86 x 300 MW
Gas	100 x 50 MW	142 x 50 MW

The installed steam generation capacity will exceed that of gas by a factor of 3 during 1991-1995, and by a factor of 4 during the following five years.

1/ Which is the earliest time for a local manufacturing industry to mature.

Table 2.20. Estimated transformation capacity (MVA), 1981-2000

Country	Number of transformations a/	Period 1981-85	1986-90	1991-95	1996-2000
Bahrain	3	1 365	2 289	1 494	1 914
Egypt	5	11 620	26 645	22 615	29 965
Iraq	5	10 665	17 225	28 145	45 650
Jordan	4	1 244	1 536	2 540	4 024
Kuwait	4	7 800	12 000	11 472	15 532
Lebanon	4	3 432	6 912	13 880	27 924
Oman	3	249	252	300	284
PDRY	3	138	183	333	537
Qatar	3	1 125	1 125	780	1 047
Saudi Arabia	5	22 265	46 515	34 980	49 895
Syria	4	5 212	6 900	10 752	17 012
United Arab Emirates	4	5 380	8 652	7 720	10 336
Yemen Arab Republic	3	483	798	1 548	3 135
ECWA region		70 978	131 032	136 559	207 255

a/ Including one step-up transformation

Source: Joint ECWA/UNIDO Industry Division

Table 2.21. Average annual increase in transformation capacity (MVA), 1980-2000

Country	Period 1981-85	1986-90	1991-95	1996-2000
Bahrain	273	458	299	383
Egypt	2 324	5 329	4 523	5 993
Iraq	2 133	3 445	5 629	9 130
Jordan	249	307	508	805
Kuwait	1 560	2 400	2 294	3 106
Lebanon	686	1 382	2 776	5 585
Oman	50	50	60	57
PDRY	28	37	67	107
Qatar	225	225	156	209
Saudi Arabia	4 453	9 303	6 996	9 979
Syria	1 042	1 380	2 150	3 402
United Arab Emirates	1 076	1 730	1 544	2 067
Yemen Arab Republic	97	160	310	627
ECWA region	14 196	26 206	27 312	41 451

Source: Joint ECWA/UNIDO Industry Division

Table 2.22. Projected increase in generating units (MW) in ECWA region 1980-2000

	1981 - 1985 Gen.cap. increase	Unit nos. and size	1986 - 1990 Gen.cap increase	Unit nos. and size	1991 - 1995 Gen.cap. increase	Unit nos. and size	1986 - 2000 Gen.cap. increase	Unit nos. and size
Bahrain								
Steam	255	2 x 70, 1 x 100	427	4 x 100	279	2 x 150	357	2 x 150
Gas	109	2 x 50	183	1 x 30, 3 x 50	119	2 x 50	153	3 x 50
Egypt								
Steam	1 227	6 x 150, 1 x 300	2 814	10 x 150, 5 x 300	2 931	6 x 150, 7 x 300	3 883	13 x 300
Gas	279	9 x 30	640	5 x 30, 10 x 50	687	14 x 50	911	18 x 50
Iraq								
Steam	1 109	1 x 150, 6 x 300	1 791	6 x 300	4 503	15 x 300	7 304	24 x 300
Gas	-	-	-	-	-	-	-	-
Jordan								
Steam	232	2 x 33, 1 x 66 1 x 100	286	3 x 66, 1 x 100	478	2 x 100, 2 x 150	757	1 x 150, 2 x 300
Gas	12	1 x 30	15	-	30	1 x 50	48	1 x 50
Kuwait								
Steam	515	3 x 80, 1 x 300	792	2 x 100 2 x 150 1 x 300	757	1 x 150 2 x 300	1 025	1 x 150, 3 x 300
Gas	515	10 x 50	792	16 x 50	757	15 x 50	1 025	20 x 50
Lebanon								
Steam	686	3 x 66, 4 x 120	1 382	5 x 100, 6 x 150	2 776	13 x 100, 6 x 150, 2 x 300	5 585	19 x 300
Gas	-	-	-	-	-	-	-	-
Oman								
Steam	38	1 x 50	67	1 x 66	80	1 x 100	102	1 x 100
Gas	-	-	-	-	-	-	-	-
PDRY								
Steam	37	1 x 40	49	1 x 66	89	1 x 100	143	1 x 150
Gas	-	-	-	-	-	-	-	-
Qatar								
Steam	-	-	-	-	-	-	-	-
Gas	300	6 x 50	300	6 x 50	208	4 x 50	279	6 x 50

Table 2.22 Projected increase in generating units (MW) in ECWA region 1980-2000 (Continued)

	1981 - 1985 Gen.cap. increase	Unit nos. and size	1986 - 1990 Gen.cap. increase	Unit nos. and size	1991 - 1995 Gen.cap. increase	Unit nos. and size	1996 - 2000 Gen.cap. increase	Unit nos. and size
Saudi Arabia								
Steam	1 425	10 x 150	2 977	10 x 150, 5 x 300	2 239	3 x 150, 6 x 300	3 193	1 x 150, 10 x 300
Gas	2 030	41 x 50	4 242	85 x 50	3 190	64 x 50	4 550	91 x 50
Syria								
Steam	615	2 x 150, 1 x 300	814	2 x 150, 2 x 300	1 269	4 x 300	2 007	7 x 300
Gas	-	-	-	-	-	-	-	-
United Arab Emirates								
Steam	958	9 x 75, 2 x 150	1 609	7 x 100, 6 x 150	1 420	6 x 150, 2 x 300	1 902	6 x 300
Gas	75	2 x 40	121	3 x 50	108	2 x 50	145	3 x 50
Yemen Arab Rep.								
Steam	103	2 x 50	213	2 x 100	413	1 x 100, 2 x 150	836	1 x 100, 1 x 150, 2 x 300
Gas	-	-	-	-	-	-	-	-
ECWA								
Steam	7 200		13 221		17 234		27 094	
Gas	3 320		6 293		5 099		7 111	
ECWA								
STEAM units and size	2 x 33, 3 x 50, 2 x 70, 3 x 80, 4 x 120, 9 x 300	1 x 40, 4 x 66, 9 x 75, 2 x 100, 21 x 150	5 x 66, 36 x 150	21 x 100, 19 x 300	18 x 100, 38 x 300	28 x 150	2 x 100, 86 x 300	7 x 150,
GAS units and size	10 x 30, 59 x 50	2 x 40	6 x 30	125 x 50	102 x 50		142 x 50	

Source: Joint ECWA/UNIDO Industry Division.

2.5 Transformers

Transformers can be divided into three main categories[1/] corresponding to the line voltages in the network, as shown in table 2.23.

Table 2.23 Transformer categories

Category	Capacity range (MVA)	Line voltage (KV)
1. Distribution	0.25 - 1.25	up to 22
2. Medium power	6 - 40	33 to 220
3. Large power	75 - 200	132 to 500

Source: Joint ECWA/UNIDO Industry Division.

The projected growth of transformation capacity is divided among practical transformer sizes on the basis of the number of transformations envisaged in the network as stated in table 2.20. The criteria are shown in table 2.24.

Table 2.24 Projected capacity per cent per transformer size

Number of transformations	Capacity (per cent)						
	0.25 MVA	1.25 MVA	6 MVA	15 MVA	40 MVA	75 MVA	200 MVA
3	17	17	33	33	-	-	-
4	13	13	13	13	17	33	-
5	10	10	10	10	7	13	40

Source: Joint ECWA/UNIDO Industry Division.

The results of this process are shown in tables 2.25, 2.26 and 2.27. For the region as a whole, the average annual increase in transformation capacity is projected as follows:

Transformer category	Average annual increase in capacity (MVA)			
	1981-1985	1986-1990	1991-1995	1996-2000
0.25-1.25 MVA	3,165	5,730	6,041	9,220
6-40 MVA	4,762	8,520	9,041	13,853
75-200 MVA	6,269	11,956	12,230	18,378

1/ This division is basically made in view of the different manufacturing requirements of each category.

The projected number of transformers per category is derived from the above tables and is given in table 2.28.

Table 2.25 Projected growth of distribution (0.25-1.25MVA) Transformers capacity (MVA), 1980-2000

Country	Average annual increase (MVA			
	1981-1985	1986-1990	1991-1995	1996-2000
Bahrain	91	156	100	127
Egypt	468	1066	905	1198
Iraq	427	689	1126	1828
Jordan	63	74	128	201
Kuwait	390	600	573	775
Lebanon	173	331	694	1395
Oman	17	17	20	20
PDRY	9	12	22	35
Qatar	75	76	52	69
Saudi Arabia	891	1860	1398	1994
Syria	260	346	536	852
UAE	269	450	384	517
YAR	32	53	103	209
ECWA region	3165	5730	6041	9220

Source: Joint ECWA/UNIDO Industry Division.

Table 2.26. Projected growth of medium power (6-40 MVA) Transformers capacity (MVA), 1980-2000

Country	Average annual increase (MVA)			
	1981-1985	1986-1990	1991-1995	1996-2000
Bahrain	182	302	199	256
Egypt	620	1 439	1 221	1 594
Iraq	574	930	1 499	2 438
Jordan	106	132	210	334
Kuwait	655	1 008	955	1 293
Lebanon	287	595	1 158	2 330
Oman	33	33	40	38
P D R Y	19	25	45	72
Qatar	150	149	104	140
Saudi Arabia	1 184	2 512	1 865	2 660
Syria	438	579	895	1 419
U A E	449	709	643	861
Y A R	65	107	207	418
ECWA region	4 762	8 520	9 041	13 853

Source : Joint ECWA/UNIDO Industry Division.

Table 2.27. Projected growth of large power (75 - 200 MVA) Transformers capacity (MVA) 1980-2000

Country	Average annual increase (MVA)			
	1981-1985	1986-1990	1991-1995	1996-2000
Bahrain	-	-	-	-
Egypt	1 236	2 824	2 397	3 201
Iraq	1 132	1 826	3 004	4 864
Jordan	80	101	170	270
Kuwait	515	792	766	1 038
Lebanon	226	456	924	1 860
Oman	-	-	-	-
P D R Y	-	-	-	-
Qatar	-	-	-	-
Saudi Arabia	2 378	4 931	3 733	5 325
Syria	344	455	719	1 131
U A E	358	571	517	689
Y A R	-	-	-	-
ECWA region	6 269	11 956	12 230	18 378

Source: Joint ECWA/UNIDO Industry Division.

Table 2.28. Projected number of transformers in ECWA region, 1980-2000

Country	1981 - 1985							1986 - 1990						
	Transformer sizes							Transformer sizes						
	0.25 MVA	1.25MVA	6 MVA	15 MVA	40 MVA	75 MVA	200 MVA	0.25 MVA	1.25 MVA	6 MVA	15 MVA	40 MVA	75 MVA	200 MVA
Bahrain	912	182	76	30	-	-	-	2 288	458	95	38	-	-	-
Egypt	4 648	930	194	77	19	20	23	10 660	2 132	444	178	47	46	53
Iraq	4 268	854	178	72	18	19	21	6 884	1 378	287	115	30	30	34
Jordan	628	126	27	11	5	5	-	740	148	33	12	7	7	-
Kuwait	3 900	780	163	65	33	34	-	6 000	1 200	250	100	51	53	-
Lebanon	1 728	346	72	29	14	15	-	2 488	498	426	42	21	22	-
Oman	168	34	14	5	-	-	-	172	34	14	5	-	-	-
P D R Y	92	18	8	3	-	-	-	124	25	11	4	-	-	-
Qatar	764	153	62	25	-	-	-	764	153	64	24	-	-	-
Saudi Arabia	8 908	1 782	371	148	37	40	45	18 608	3 722	775	310	81	81	93
Syria	2 608	522	109	43	22	23	-	3 452	695	144	57	29	30	-
U A E	2 692	538	112	45	22	24	-	4 396	879	185	61	37	39	-
Y A R	324	65	27	11	44	-	-	528	106	44	18	-	-	-
Total number of transformers	31 640	6 330	1 413	564	214	180	89	57 104	11 428	2 772	964	303	308	180
Total capacity (MVA)	7 910	7 912	8 465	8 468	6 868	13 522	17 832	14 403	14 402	14 811	14 597	12 108	24 235	36 475

(Continued...)

Table 2.28. (Continued)

	1991 - 1995							1996 - 2000						
	Transformer sizes							Transformer sizes						
	0.25MVA	1.25MVA	6 MVA	15 MVA	40 MVA	75 MVA	200 MVA	0.25 MVA	1.25 MVA	6 MVA	15 MVA	40 MVA	75 MVA	200MVA
Bahrain	996	199	83	33	-	-	-	1 272	254	106	43	-	-	-
Egypt	27 860	1 393	290	116	29	30	35	11 976	2 395	499	200	50	53	60
Iraq	11 260	2 214	469	188	46	50	56	18 288	3 656	762	305	76	81	91
Jordan	1 272	256	53	21	11	11	-	2 008	402	84	34	17	18	-
Kuwait	5 724	1 146	239	95	48	51	-	7 760	1 552	323	129	65	69	-
Lebanon	6 936	1 387	289	116	58	62	-	13 952	2 790	582	233	117	124	-
Oman	200	40	17	7	-	-	-	192	38	16	6	-	-	-
P D R Y	220	44	19	7	-	-	-	356	71	30	12	-	-	-
Qatar	520	104	44	17	-	-	-	696	140	58	23	-	-	-
Saudi Arabia	13 980	2 796	582	233	59	62	70	19 940	3 988	831	332	83	88	100
Syria	5 360	1 072	223	89	45	48	-	8 516	1 703	355	142	71	75	-
U A E	3 844	768	160	64	32	34	-	5 168	1 034	215	87	43	46	-
Y A R	1 028	206	86	34	-	-	-	2 088	418	174	70	-	-	-
Total number of transformers	79 200	11 625	2 554	1 020	328	348	161	92 212	18 441	4 035	1 616	522	554	251
Total capacity (MVA)	15 100	15 099	15 845	15 857	13 464	26 935	34 260	23 060	23 060	24 226	24 258	20 800	41 650	50 203

Source: Joint ECWA/UNIDO Industry Division.

2.6 Other power equipment

(a) Boilers: The number of boilers is equal to the number of steam turbines and, according to the envisaged increase in generating units given in table 2.22, it will amount to 84 boilers in the period 1991-1995, and 95 in the period 1996-2000. Boilers are normally procured from specialized chemical equipment manufacturers.

(b) Transmission and distribution lines: The available statistical data are inadequate for developing norms (MW/km, etc.) that can be used for projecting the growth of those products. In terms of quantity and value, transmission lines account for a small ratio of cables and wires relative to distribution lines. Cables and wires are normally procured from specialized manufacturers.

A separate study is being conducted by the Joint ECWA/UNIDO Industry Division on cables and wires.

(c) Switchgear: Projections of switchgear will be made in a subsequent study. Other power equipment are not of high priority at this time.

2.7 Projected investment in electric power equipment

The projected average annual investment in turbines and generators (including control and thermal equipment) and transformers, corresponding to the projected increase in the capacities of those equipment, is given in table 2.29. Investment figures pertain to ex-factory cost of equipment, and are based on approximate prices[1/] provided by international manufacturers.

1/ 94.000 US$ per MW for turbines and generators including control and thermal equipment, 11,300 US$ per MVA for small (distribution) transformers, 9,600 US$ per MVA for medium power transformers, and 7,000 US$ for large power transformers all in 1979 constant prices.

Table 2.29. Projected average annual increase in investment for turbines, generators and transformers (million US$ at constant 1979 prices), 1980-2000

	1981-1985	1986-1990	1991-1995	1996-2000
(a) Turbines, generators and associated equipment	247	448	473	722
(b) Distribution (0.25 - 1.25 MVA) transformers	36	65	68	104
(c) Medium power (6-40 MVA) transformers	46	82	87	133
(d) Large power (75 -200 MVA) transformers	44	84	86	129
Total	373	673	714	1 088

Source: Joint ECWA/UNIDO Industry Division.

CHAPTER 3

THE ELECTRIC POWER EQUIPMENT INDUSTRY

3.1 General

The topics discussed in this chapter are:

(a) Characteristics of the power equipment industry;

(b) Existing and planned power equipment industries in the ECWA region;

(c) The envisaged regional industry;

(d) Selection of products for the regional industry.

3.2 Characteristics of the industry

Heavy power equipment is invariably designed according to the customer's specifications. Each customer has certain standards and rules of his own; and each country has its own regulations and minimum safety specifications for electrical equipment.

Economies of scale in power generation and transmission, or sometimes the geographical remoteness of main power sources, have forced electricity authorities to seek larger generating unit sizes and higher transmission voltages. The industry has thus been forced to concentrate enormous power in single units and to strive for higher voltages. In 1960, for example, a 200-MVA hydroelectric generator was considered to be very large; in 1977 three hydroelectric generators, each rated at 718-MVA[1/], were installed at the Grand Coulee project in the United States. In 1951, a 100-MW steam turbogenerator was the largest unit ever built in Europe; today a 1,300-MW steam turbogenerator is probably not the largest unit produced. Before 1950, the highest transmission voltage was 220 kV, at present it is around 1,000 kV.

The high transmission voltages and large unit sizes have affected the industry in many ways. High voltages necessitate the development of better insulation materials and special manufacturing and testing techniques and equipment.

1/ Each unit weighs 2,500 tons; the rotor alone weighs 1,400 tons and rotates at the rate of 86 revolutions per minute.

Large unit sizes also require higher quality components, especially forgings and castings, and more powerful and larger production equipment and facilities. One unit may take as much as 25 per cent of the production capacity of the factory and stay on the production floor for up to two years.

The large size and irregularity orders cause slack production periods and make programming of the overall production activity very critical. Large orders and long-lead times demand large amounts of working capital; powerful production equipment and facilities require huge capital investment.

Manufacturers of heavy power equipment produce a wide range of products to stabilize the work-load at the factory, and to recover the cost of research and development. The ability of manufacturers to offer a complete line of products has marketing advantages as well.

Manufacturing techniques vary according to product group and unit size. The manufacture of transformers, which are static machines, differs from the manufacture of generators and turbines, which are rotating machines. Among rotating machines, steam equipment is very different from hydroelectric equipment. Moreover, manufacturing a 100-MW steam turbine is quite different from manufacturing a 600-MW steam turbine. Thus, product group or unit size form a basis for specialization by small firms, and by divisions or plants of large international concerns.

The cost of materials dominates the cost of production. The most important materials for manufacturing power equipment are copper and steel. Other important materials include insulation materials such as paper, porcelain bushings, and transformer oil. Steel castings and forgings are also used quite extensively. In industrialized countries, there are specialized foundries and forging plants from which power equipment manufacturers purchase their requirements of semi-finished parts while freeing themselves to concentrate on design, machining, testing and assembly operations. In developing countries, some manufacturers have established their own facilities for casting and forging. This often results in higher production costs and inferior quality, at least in the short run. Another alternative has been provided by some international manufacturers who have developed special designs (e.g. parts normally produced by cast steel are replaced by welded pieces) for manufacturers of power equipment in developing countries.

The basic technological principles for the manufacture of power equipment have not changed much since the early days of the industry. Still, tremendous R & D efforts are made to produce the ever larger equipment demanded by customers. Moreover, the introduction of nuclear energy for the generation of electrical power forced all of the larger power equipment manufacturers to become involved not only in the construction of steam power plants based on nuclear energy, which calls for new designs and technology, but also in the construction of nuclear reactors. This again necessitated a tremendous amount of research and heavy expenditure. In general, R & D expenditures range from 8 to 10 per cent of sales.

The market for power equipment consists of a limited number of customers, mainly electricity authorities and utility companies.1/ Customer preferences are based not only on price and quality of equipment but also on the compatibility of the new equipment with existing power systems, previous experienece with the manufacturer, speed of delivery, ease of ordering, quality of the after-sales service, and terms of credit.

The huge capital investment and high R & D expenditure as well as the limited number of customers are factors that caused keen competition among international manufacturers of power equipment. Many mergers took place with the result that the industry at present is dominated by a few large companies. Those multinationals have established industrial operations of various forms in developing as well as industrialized countries in order to secure their markets.

The manufacture of power equipment in developing countries faces the following problems:

(a) Development of local technical skills;

(b) Development of the organization which can implement projects of this scope;

(c) Acquisition of technology on a continuous basis;

(d) Development of supporting industries which, at least in the short-term, could increase the cost of production and the quality of the product.

Before starting their own power industries, developing countries must formulate comprehensive plans to solve the above problems. In the case of the supporting industries which include foundry and forging plants (castings and forged components), chemical equipment (boilers, etc.), electronic equipment (instrumentations and communication systems), etc., their potential role in serving other industries such as heavy mining equipment should be taken into account. Moreover, it would be very useful to examine the experience of countries like Spain, Brazil, India, Mexico and Pakistan to see how they resolved the above issue.

1/ Also industrial firms (such as chemical-processing plants), railroads, and marine transportation.

3.3 Existing[1] and planned industries

The manufacture of power equipment in the ECWA region is very limited and undertaken on a national basis.

Bahrain: A bare-cables factory was scheduled to start production in February 1978. It was planned to have an initial capacity of 4,000 tons of aluminum cables which would increase to 12,000 tons by 1981.

Egypt: The transformer industry began in Egypt in 1950, and is presently the responsibility of the Nasr Company. The company produces certain sizes of small (distribution) transformers, and probably some low medium power transformers as well. Another company (ALMACO) is responsible for producing electrical products including switchgear. Cables also produced, with the technical assistance of the World Agency for the Development of the Cables Industry, Switzerland. The data on the specifications of the above products and the capacities of the factories are not available.

Iraq: The transformer industry began in 1967. Production follows the Soviet standards, with Soviet technical assistance. A plan is believed to have been prepared for producing cables.

Jordan: Present manufacturing activities are restricted to the production of poles for distribution lines and street lighting. This is done by the Jordan Electricity Authority (JEA) which owns a concrete pole factory (1,253 poles produced in 1976) and the Jordan Electric Power Company (JEPCO) which produces metal poles to meet its own needs. A cable and wire factory was planned to go into operation before 1980 (at a cost of 700,000 dinars), and another for producing simple plastic wires.

Kuwait: A project for setting up a cable factory is being studied. There are no data on its progress.

Lebanon: The cable and wire industry produces cables for a variety of applications:

(a) Low-tension and medium-tension cables;
(b) Rigid and flexible cables;
(c) Lift cables;
(d) Power cables;
(e) Control cables;
(f) Audio-frequency cables.

The total production in 1972 was 4,565 tons valued at about 16.5 million Lebanese pounds.

1/ As of 1978.

Saudi Arabia: Only metallic poles are known to be produced in the country.

Syria: The cable factory in Damascus produces insulated and bare wires and cables. Its production capacity was 5,000 tons in 1977. Another cable factory, with a capacity of 2,500 tons of copper and 4,000 tons of aluminium cables, was planned to start to start production in 1978. Concrete poles are produced in many factories and meet all of Syria's needs.

Although data on possible supporting industries are not available, it is certain that even if they exist, they would be inadequate for heavy power equipment (turbines, generators, power transformers).

3.4 The envisaged regional industry

The manufacture of heavy power equipment is analysed in this study in the context of a regional industry whose precise form will be determined in a subsequent feasibility study. The regional industry will cater to the combined markets of the region, and may choose to establish factories in several ECWA countries.

The advantages of a regional industry vis-a-vis a national industry, in general, are summarized below:

(a) Larger market, which reduces the unit cost of production and increases the local added value;

(b) More efficient utilization of the region's resources (capital, skilled labour, etc.);

(c) Development of regional co-operation with resulting economic and social benefits.

On the other hand, a regional industry faces unique problems stemming from its ties with numerous governments, electricity authorities and utility companies. Without strong and continuous co-operation among the governments of the region, its chances for success are negligible.

The success of the proposed regional industry depends to a great extent on its ability to form close linkages with electricity authorities and governments of the region as well as international manufacturers of power equipment. The objectives of those linkages are summarized below:

(a) With the electricity authorities:

(i) To plan properly its production activities;
(ii) To standardize the capacities and specifications of products;
(iii) To provide after-sale logistic services relating to the installation and commissioning of equipment, and training the staff for its operation and maintenance.

(b) With the governments:

(i) To utilize local educational institutions, such as universities and training centres, in preparing the staff for subsequent specialized training in the factory or abroad;

(ii) To resolve legal, financial, and other issues requiring decisions at the government level, e.g. trade policies, acquisition of capital, etc.

(c) With international manufacturers of power equipment:

To acquire all the necessary know-how and support within the context of technology transfer.[1/]

3.5 Selection of products for the regional industry

The selection of products for the regional industry is based on the following criteria:

(a) Size of the market: The ability of the regional market to absorb the output of a viable manufacturing plant, and concurrently, the inability of national markets to individually absorb the output of such a plant;

(b) Status of technology: products whose technology is expected to become obsolete are discarded;

(c) Selected products are put in order of priority according to their relative value in the power system, their impact on other equipment in the system, their role in the transfer of technology to the region and the resources required for producing them.

Application of the above criteria to turbines, generators, and transformers indicates that they are potential candidates for the regional industry.

1/ The various aspects of technology transfer are discussed in parts 2 and 3 of this volume.

ANNEX

LIST OF MAIN ELECTRIC POWER EQUIPMENT

MAIN ELECTRIC POWER PRODUCTS

1. <u>Thermal-generating plants</u>

Turbines
Generators
Transformers
Compressors and drives
Boilers
Pumps
Condensers
Heaters
Tanks
Strainers
Water-treatment equipment
Cooling equipment
Chemical-feed equipment
Combustion control and instrumentation
Indicating thermometers
Gauges
Purification systems
Hydrogen-oxygen generation facilities
Inter-communication systems
Motors
Switchboards and relay panels
Bus ducts
Motor control centres
Storage batteries
Battery charging equipment
Cables and wires
Isolators
Auxiliary equipment

2. <u>Transformer stations</u>

Transformers
Capacitors
Switchgear
Control and protection equipment
Monitoring instrumentation
Distribution boards
Isolators
Circuit breakers
Communication equipment
Cables and wires
Auxiliary equipment.

3. <u>Transmission and distribution lines</u>

Wires
Towers
Poles
Cables
Insulators
Instrumentation
Auxiliary equipment.

VOLUME II

PART 2

PRE-FEASIBILITY STUDY ON TURBINES AND GENERATORS

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LIST OF ABBREVIATIONS

AC	Alternating current
bar	Atmospheric pressure 13.7 lbs. per square inch
^oC	Degree centigrade
DC	Direct current
GT	Gas turbine
HP	High pressure
HV	High voltage
IP	Intermemdiate pressure
kg/sec	Kilogram per second
kJ/kW	Kilojoule per kilowatt
kV	Kilovolt
LP	Low pressure
m	Metre
m^2	Square metre
m^3	Cubic metre
m.s.	Mild steel
MVA	Mega voltampere
MW	Megawatt
MWh	Megawatt hour
NC	Numerical control
OJT	On-the-job training
PDRY	People's Democratic Republic of Yemen
R & D	Research and development
rpm	Revolutions per minute
sec	Second
ST	Steam turbine
t	Ton
US	United States
UAE	United Arab Emirates
YAR	Yemen Arab Republic
Yr	Year

LIST OF ABBREVIATIONS

AC	Alternating current
bar	Atmospheric pressure 13.7 lbs. per square inch
^oC	Degree centigrade
DC	Direct current
GT	Gas turbine
HP	High pressure
HV	High voltage
IP	Intermemdiate pressure
kg/sec	Kilogram per second
kJ/kW	Kilojoule per kilowatt
kV	Kilovolt
LP	Low pressure
m	Metre
m^2	Square metre
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m.s.	Mild steel
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MWh	Megawatt hour
NC	Numerical control
OJT	On-the-job training
PDRY	People's Democratic Republic of Yemen
R & D	Research and development
rpm	Revolutions per minute
sec	Second
ST	Steam turbine
t	Ton
US	United States
UAE	United Arab Emirates
YAR	Yemen Arab Republic
Yr	Year

INTRODUCTION

The pre-feasibility study presented in this volume pertains to the manufacture of turbines and generators.

The study is based on the results and conclusions arrived at in part 1 of this volume which analysed the basic economic and technological aspects relating to electric power equipment, and on the manufacturing data provided by BBC Brown Boveri and Company of Switzerland. General Electric, USA, provided important inputs for this study. The data on local wages, cost of construction, etc. were supplied by leading consulting firms and construction companies in the ECWA region. Other inputs necessary for conducting the study were generated by the Joint ECWA/UNIDO Industry Division.

The scope of this study comprises the following:

(1) Project parameters: characteristics of the products, plant capacity, the production processes, maturation period, development of local added value, etc.;

(2) Structure of the factory's organizations;

(3) The type of technology needed, and the means for acquiring it. Special emphasis is placed on the training function;

(4) Manufacturing requirements: facilities, machinery, materials, and personnel;

(5) Financial implications, including size of investment, payback period and rate of return.

It should be emphasized at this point that the results obtained in this study are broadly indicative, and must be substantiated by a detailed feasibility study where many parameters, which are not well defined at this stage, could be completely specified, e.g. location of the factory, precise specifications of the product, product mix, plant capacity, etc.

CHAPTER 1

BACKGROUND

1.1 General

The information and conclusion presented in this chapter are based on part 1 of this report, which provides basic background for this pre-feasibility study. It encompasses the following topics:

(a) Projected size of the market for turbines and generators;
(b) The types of turbines and generators selected for this study;
(c) Existing power equipment and supporting industries.

1.2 The projected market for turbines and generators

The size of the market for turbines and generators in the ECWA region between 1980 and 2000 is projected as follows:

Table 1.1 Projected demand for installed generation capacity (MW) in ECWA region 1980-2000

Country	Average annual increase (MW)			
	1981-1985	1986-1990	1991-1995	1996-2000
Total ECWA region	2 628	4 763	5 029	7 679
Bahrain	76	127	83	106
Egypt	387	887	753	997
Iraq	355	574	937	1 519
Jordan	52	63	106	167
Kuwait	325	499	477	646
Lebanon	143	287	577	1 170
Oman	14	14	16	20
PDRY	7	10	18	25
Qatar	62	62	44	58
Saudi Arabia	750	1 548	1 164	1 660
Syria	216	287	447	707
UAE	224	360	321	430
YAR	27	45	86	174

Source: Joint ECWA/UNIDO Industry Division; reproduced from table 2.16, part 1, volume II.

1.3 The selected products

The selection of turbines and generations for regional manufacture is based on economic and technological considerations:

(a) The regional market can, even now, absorb the output of a viable manufacturing plant which corresponds to a minimum of 2,000 to 3,000 MW per year.1/ On the other hand, none of the national markets, including Saudi Arabia or Iraq, could individually absorb the output of such a plant during the projection period (1980-2000);

(b) The basic technology of turbines and generators has been fairly stable. Future research efforts will mainly pertain to the development of new metal alloys and insulation materials and better cooling systems as well as more precise methods for producing, assembling, and testing the ever-increasing physical sizes and power capacities of those products. The challenge facing manufacturers will be how to "pack" more power per unit volume into turbines and generators, and to solve the problems caused by high operational pressures and temperatures;

(c) Turbines and generators are the most expensive items in the power system. Their combined cost amounts to about 40 per cent of the generating plant's cost;

(d) Turbines and generators are the core of the power system. They have a decisive influence on other equipment in the system, e.g. ratings of power transformers, transmission line voltages;

(e) Compared to other power equipment, including large power transformers, the level of technology required for manufacturing turbines and generators is very high. Consequently, their manufacture significantly enhances the transfer of technology to the region.

The product types selected for this study are steam turbines, gas turbines, and generators. This selection is based on economic consideration and takes into account:

(a) The region's endowment of natural resources, indicating that the potential for hydroelectric generation is limited, whereas gas and oil are abundant;

(b) The observed trend in the region towards thermal power plants;

1/ These figures were supplied by international manufacturers based on their past experiences. They can only be considered as approximate figures at this stage because they depend on many parameters which are not well defined now, and which will be specified in a detailed feasibility study. Among those parameters are: product mix, location of the factory, etc.

(c) The observed trend in the region towards integrated national networks, and, consequently, larger generating unit sizes. The implication is that diesel generation will be phased out;

(d) The complexities associated with the manufacture, operation, and safety control of nuclear power plants and the high cost of uranium, as well as the large commercially competitive sizes (about 600 MW), practically eliminate the possibility of manufacturing them in the region - at least during the projection period.

The envisaged unit sizes are:

ST	:	100, 150, 300 MW
GT	:	50, 100 MW

This range of sizes has the following advantages:

(a) It covers the envisaged requirements of the region's networks. At present, a unit size of 100 MW is considered to be large, but towards the end of the next decade, units will increasingly be in the 300-MW category;

(b) It enhances efforts to standardize the region's networks and equipment with resulting economic and operational advantages: subregional and regional integration of networks, etc.;

(c) It makes the manufacturing operation more economical: fewer designs, less inventory, higher factory loading, etc.

1.4 Existing power equipment and supporting industries

There are no factories for the manufacture of turbines and generators in the ECWA region, and as yet no national or regional plans for their construction.

Although the information available concerning supporting industries is inadequate, it is clear that materials and components of the necessary specifications, and in the required quantities and physical sizes, cannot be supplied. The materials1/ include cast iron, cast steel, cast aluminium, steel sheets, steel plates, and steel tubes, rolled and drawn steel sections, copper rods and strips, forgings and insulating materials. Thus, once this project has been evaluated in a feasibility study it will be necessary to formulate plans for the development of the industrial infrastructure.

1/ Refer to section 4.3 for more details.

CHAPTER 2

DEFINITION OF THE PROJECT

2.1 General

The topics discussed in this chapter are:

(a) Features of the products;
(b) Joint manufacture of turbines and generators;
(c) Plant capacity;
(d) The production processes;
(e) The maturation period;
(f) Development of the localization level;
(g) Manufacturing linkages with other products.

2.2 Features of the products

The data used in this study relating to manufacturing requirements, prices, costs, etc. are based on specific typical products. Certain parameters, such as material cost and selling prices, will deviate from those given in this report, depending on the product mix which will be determined in the feasibility study. However, for our purposes here, these data may be regarded as applicable to the entire product range, i.e. 100-150 and 300-MW steam turbines; 50- and 100-MW gas turbines, the corresponding generators and associated control and thermal equipment.

The main features of the typical products are set out below:

(a) Turbines

(i) 300-MW steam turbine

Generator output	305 MW
Speed	3,000 rpm
Steam flow at HP stop valve	243.35 kg/sec
Heat rate	2.15 kg/kW
Steam pressure at HP stop valve	160 bar
Steam temperature HP stop valve	538°C
Steam pressure at HP exhaust	44.77 bar
Steam temperature of HP exhaust	347.6°C
Steam pressure at IP stop valve	41.37 bar
Steam temperature IP stop valve	538°C
Steam pressure at LP inlet	5.19 bar
Steam temperature LP inlet	254°C
LP exhaust pressure	0.035 bar
Cooling water temperature	10°C
Final feedwater temperature	255°C

(ii) <u>150-MW steam turbine</u>

Generator output	158 MW
Speed	3,600 rpm
Steam flow at H stop valve	135.37 kg/sec
Heat rate (with auxiliaries)	2.31 kJ/kW
Steam pressure at HP stop valve	125 bar
Steam temperature HP stop valve	537°C
Steam pressure at HP exhaust	33.8 bar
Steam temperature HP exhaust	350°C
Steam pressure at IP stop valve	30.4 bar
Steam temperature IP stop valve	537°C
Steam pressure at LP inlet	5.5 bar
Steam temperature LP inlet	297°C
LP exhaust pressure	0.101 bar
Cooling water temperature	28°C
Final feedwater temperature	238°C

(b) <u>Generators</u>

(i) <u>300-MW generator</u>, this generator can produce an output of 300 to 450 MW, depending on the length of its iron core.

The rotor is machined from a one-piece forging. The end-bells are overhung, and single-stage radial fans are mounted near each shaft-end of the rotor. The rotor winding is insulated to class F, and the rotor includes an integral damper winding.

The laminated stator core is held rigidly in the stator frame, and the core end-plates are made of non-mangnetic cast iron. The stator winding is insulated to class F. The end-winding supports are axially flexible to allow expansion.

The stator winding is cooled by water flowing from one end through hollow conductors incorporated in the winding (direct cooling). The stator core and end-plates are symmetrically cooled by hydrogen flowing from both ends axially through the core. The gas pressure used is up to 5 bars.

The rotor is symmetrically cooled by hydrogen flowing from both ends axially through the hollow conductors of the winding and through the air gap.

Excitation current is supplied from a static rectifier system, and fed to the rotor via slip-ring.

(ii) <u>150-MW generator</u>, depending on the length of its iron core, the output of this generator type may vary between 110 and 180 MW. In contrast to the 300 MW generator described in the previous paragraph, this model is entirely hydrogen-cooled.

The rotor is machined from a one-piece forging. The end-bells are overhung, and single-stage axial fans are mounted near each shaft-end of the rotor. The rotor winding is insulated to class F, and the rotor includes an integral damper winding.

The laminated stator core is held rigidly in the stator frame, and the core end-plates are of non-magnetic cast iron. The stator winding is insulated to class F. The end-winding supports are axially flexible to allow for thermal expansion and contain no metal parts.

The stator winding and core are symmetrically cooled by hydrogen gas fed from both ends and flowing radially through the core and through the winding (indirect cooling). The core end-plates and the end-windings are cooled by hydrogen. The gas pressure used is up to 3 bars.

The rotor is symmetrically cooled by hydrogen flowing from both ends axially through the hollow conductors of the winding.

Excitation current is supplied from a static rectifier system, and fed to the rotor via slip-rings, or by an AC exciter with rotating diodes.

2.3 Joint manufacture of turbines and generators

The manufacture of steam turbines, gas turbines and generators is undertaken in the same factory. Manufacturing linkages between steam and gas turbines are quite strong; the differential investment for producing gas turbines in a steam turbine factory is low. The manufacture of generators uses much of the machinery and many of the skills required for manufacturing turbines, especially those associated with rotors. Other advantages of this arrangement pertain to the utilization of floor space and transporting facilities within the factory and the ability to test the turbine-generator set as one unit which simulates their actual operation in the generating plant. In contrast, manufacturing linkages between transformers, which are static machines, and turbines and generators, which are rotating machines, are insignificant and suggest separate factories for each group.

2.4 Plant capacity

The capacity of the factory under consideration is 3,000 MW, which is greater than the minimum viable plant capacity (2,000 to 3,000 MW) as stated by leading international manufacturers of turbines and generators based on their experience in other countries. On the other hand, the 3,000 MW plant capacity will not amount to more than 50 per cent of the projected average annual increase in generation capacity in the region during the second half of the next decade, before which the factory could not reach full production.

2.5 The production processes

(a) The turbine

The rotor is the most important part of the turbine. It is assembled after a large number of small components have been separately manufactured and tested, the key item being blade forgings of varying specifications and dimensions designed for HP, IP and LP operations. The shaft comprises an upset forging, and goes through a series of machining operations; it is then put through a stress-relieving process followed by a thermal stability test. The blades, which require special manufacturing facilities, are fitted and secured over the periphery of the shaft on blade carriers by what are known as "fir-tree root connections" and the roots are machined on a root-milling machine especially designed for this purpose. The blades in the LP section are long, about one metre or more, and require very special fitting techniques. The rotor is finally assembled and dynamically balanced. The casings are then put through a series of boring operations. The blade carrier rings, diaphragms, bearings, valves and governor parts are all made in different sections of the factory and brought together for assembling. This is followed by a final check and inspection.

(b) The generator

This also follows the same general pattern of heavy machining operations as that adopted for the turbine. The rotor is a solid forging integral. The large middle section is milled along the axis to take the rotor windings. The milling is done on a special-purpose rotor slotting machine. The finished rotor is then put through the overspeed test in a special bunker.

The stator, which is fabricated from rolled m.s. plates in a true cylindrical form, is bored and then fitted with core-bars and cold-rolled circular silicon steel laminations that are especially prepared. The coils for the rotor conform to the most sophisticated processes and special insulation techniques, and are made separately in a dust-free cool area and duly impregnated or cured. For larger generators (200-MW and above), hollow copper conductors are used to allow circulation of de-mineralized water for cooling. The coils are then assembled in the stator which passes on to the final assembly with the rotor bearings and several other smaller components. As the cooling of the rotor is accomplished through hydrogen under pressure, the entire machine casing should be leak-proof. The machine then goes for complete electrical testing.

2.6 Maturation period

It is anticipated that the factory will reach full production in 13 years. The maturation period encompasses two phases:

(a) A 4-year pre-production (construction) phase;
(b) A 9-year production phase.

The length of each phase can only be estimated at this stage because it depends on the product mix, local conditions (technological infrastructure, etc.) in the country hosting the factory, etc. These factors will be defined in the feasibility study.

The build-up of manufacturing capabilities in the factory dictates that in the initial year of production unit sizes larger than 100 MW should not produced. The experience gained will be put to use in producing the larger and more complex sizes, 150 MW and 300 MW units in the future. This is in harmony with the projected generating unit sizes which will be used in the region's power systems (part 1, chapter 1).

2.7 Development of the localization level

One objective of the regional industry will be to maximize the degree of localization in a manner compatible with the development of the local technological infrastructure (skills, supporting industries, etc.) and the development of production output. Ultimately, an optimum degree of localization will be reached which can be exceeded only at the expense of disproportionately huge investments.

Tables 2.1 and 2.2 list the principal turbine and generator components, and show the increase in locally manufactured components during the production phase. The corresponding degrees of localization are shown in figures 2.1, 2.2 and 2.3 which indicate that the maximum expected degree of localization [1] will be 82 per cent for turbines, 96 per cent for generators, and 100 per cent for thermal equipment. Components such as rotors will continue to be procured, which is a practice followed by many international manufacturers of heavy power equipment [2/]. The investments needed for manufacturing these components (in foundries and forging plants) are so great that they are left to specialized suppliers (steel mills, etc.).

The procurement of components may be undertaken with the assistance of the collaborating manufacturer (licenser, partner, etc.). When such a case arises, it should be stipulated in the contractual documents.

1/ Those percentages are based on past experiences of international manufacturers of power equipment. They can, of course, deviate from those attainable in the ECWA region.

2/ Even in India, after about 20 years of manufacturing experience in turbines and generators, large alloy steel castings and forgings are not yet locally produced.

The build-up of the factory is expected to be as follows:

	Pre-production year				Production year								
	1	2	3	4	5	6	7	8	9	10	11	12	13
Production output (%)					10	20	30	40	50	60	70	80	100
Production output (MW)					300	600	900	1 200	1 500	1 800	2 100	2 400	3 000
Largest unit size						100MW			150MW			300MW	
Fixed investment (%)1/	20	20	30	30									
Cost of material (%)					10	20	30	40	50	60	70	80	100
Wages2/ (%)					70	70	70	80	80	80	100	100	100

1/ To simplify computations, it is assumed that there is no overlapping between the two phases.

2/ This build-up of personnel reflects the importance attached to the training function.

Table 2.1 Turbine components[a/] - locally manufactured and procured

Component	Initial term		Medium term		Long term	
	Locally manuf'd.	Procured	Locally manuf'd.	Procured	Locally manuf'd.	Procured
IP and HP casings		x	x		x	
LP casings	x	x	x		x	
Instrumentation	x	x	x		x	
Steam piping	x		x		x	
Rotors		x		x		
Blade carriers		x		x	x	
Shaft seals		x	x		x	
Bearing pedestals		x	x		x	
Bearings		x		x		
Blading		x		x		x
Accessories		x	x	x	x	x
Tasks for oil and control fluid	x		x		x	
Crossover and other pipes	x		x		x	
Enclosures and insulation	x		x		x	
Valve casings and supports	x		x		x	
Valves (less casing)		x	x		x	
Bearing pedestal with pumps		x	x		x	
Flaps		x	x		x	
Hydraulic and lube oil supply		x	x		x	
Main stop valve		x	x		x	
Pressure test device	x		x		x	
Starting steam strainers	x		x		x	
Control system accessories	x	x	x		x	

a/ Including control system but excluding thermal equipment.

Table 2.1 (Continued)

Component	Initial term		Medium term		Long term	
	Locally manuf'd	Procured	Locally manuf'd	Procured	Locally manuf'd.	Procured
Bought-in components of control system	x		x		x	
Patterns	x		x		x	
Assembly, inspection	x		x		x	
Overspeed test balancing		x		x		x
Control equipment		x		x		x
Share	28%	72%	66%	34%	82%	18%

Source: Power equipment manufacturer.

2.8 Manufacturing linkages with other products

Although a turbine and generator factory is designed to produce these particular pieces of equipment, it would be possible to use the equipment and facilities to produce other types of equipment made by similar manufacturing processes. Since there are always production peaks and dips in the manufacture of heavy electric power equipment, the additional products could stabilize the workload at the factory.

A sample of additional products is given below:

(a) Steam and gas turbines for industrial applications (compressor drives, chemical plants, etc.);

(b) DC generators;

(c) DC motors;

(d) Synchroners motors;

(e) Induction motors;

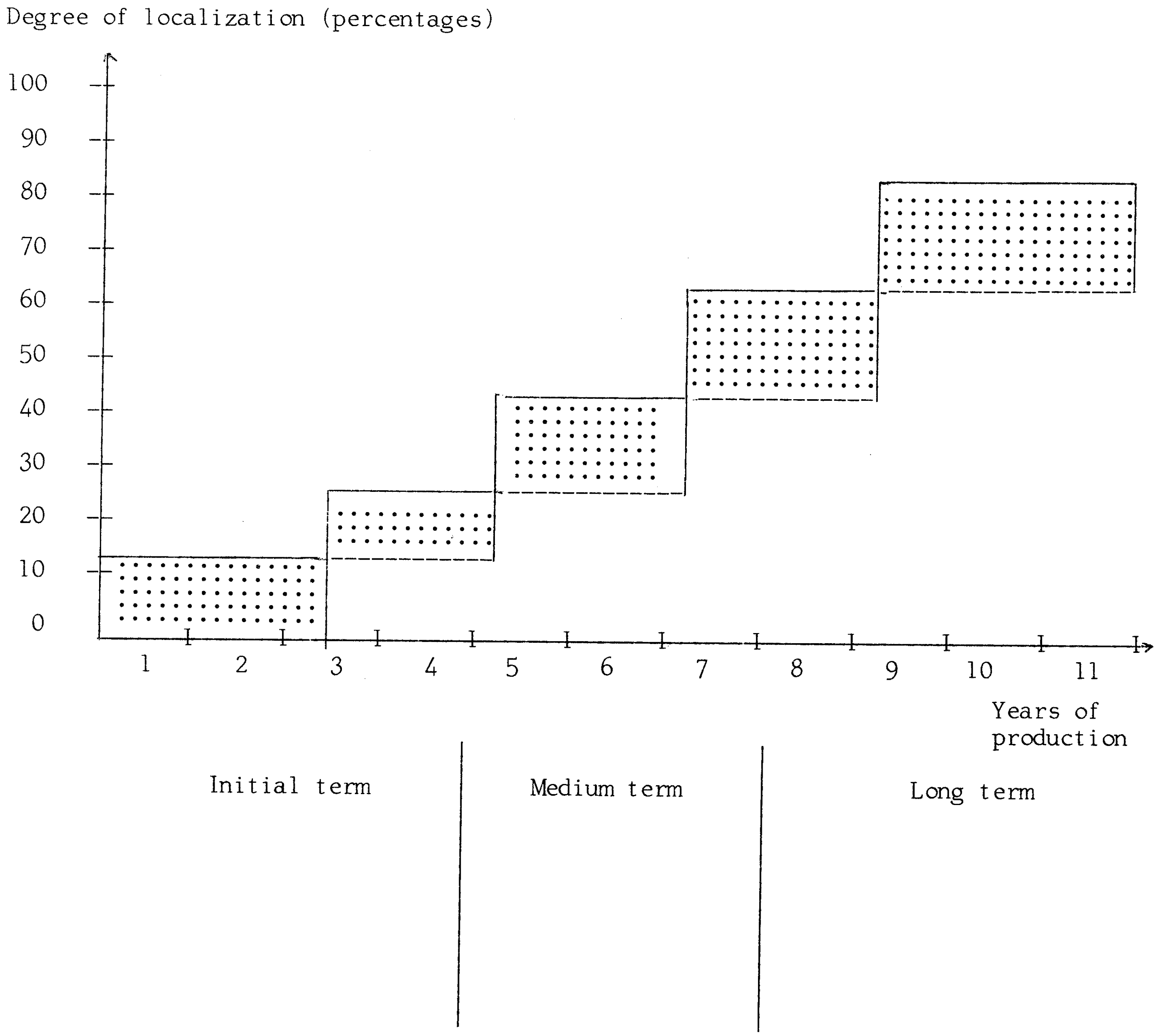
(f) Traction motors.

Table 2.2. Generator components - locally manufactured and procured

Component	Initial term		Medium term		Long term	
	Locally manuf'd.	Procured	Locally manuf'd.	Procured	Locally manuf'd.	Procured
Stator frame	x		x		x	
Stator laminations, complete		x	x		x	
Press-plates		x	x		x	
Stator end-coils		x	x		x	
Stator winding, winding the stator		x	x		x	
Terminal box		x	x		x	
Stator assembly	x		x		x	
Rotor body		x		x		x
Rotor winding		x		x		
Rotor slot-wedges		x		x	x	
Winding the rotor		x		x	x	
Overspeed test, balancing the rotor		x		x	x	
Slipring shaft		x		x	x	
End-bell		x		x	x	
Excitation, flange		x		x	x	
End-shields	x		x		x	
Slipring housing		x	x		x	
Generator accessories		x	x		x	
Thrust bearing		x		x	x	
Bearing pedestal	x		x		x	
Piping	x		x		x	
Share	32%	68%	74%	26%	96%	4%

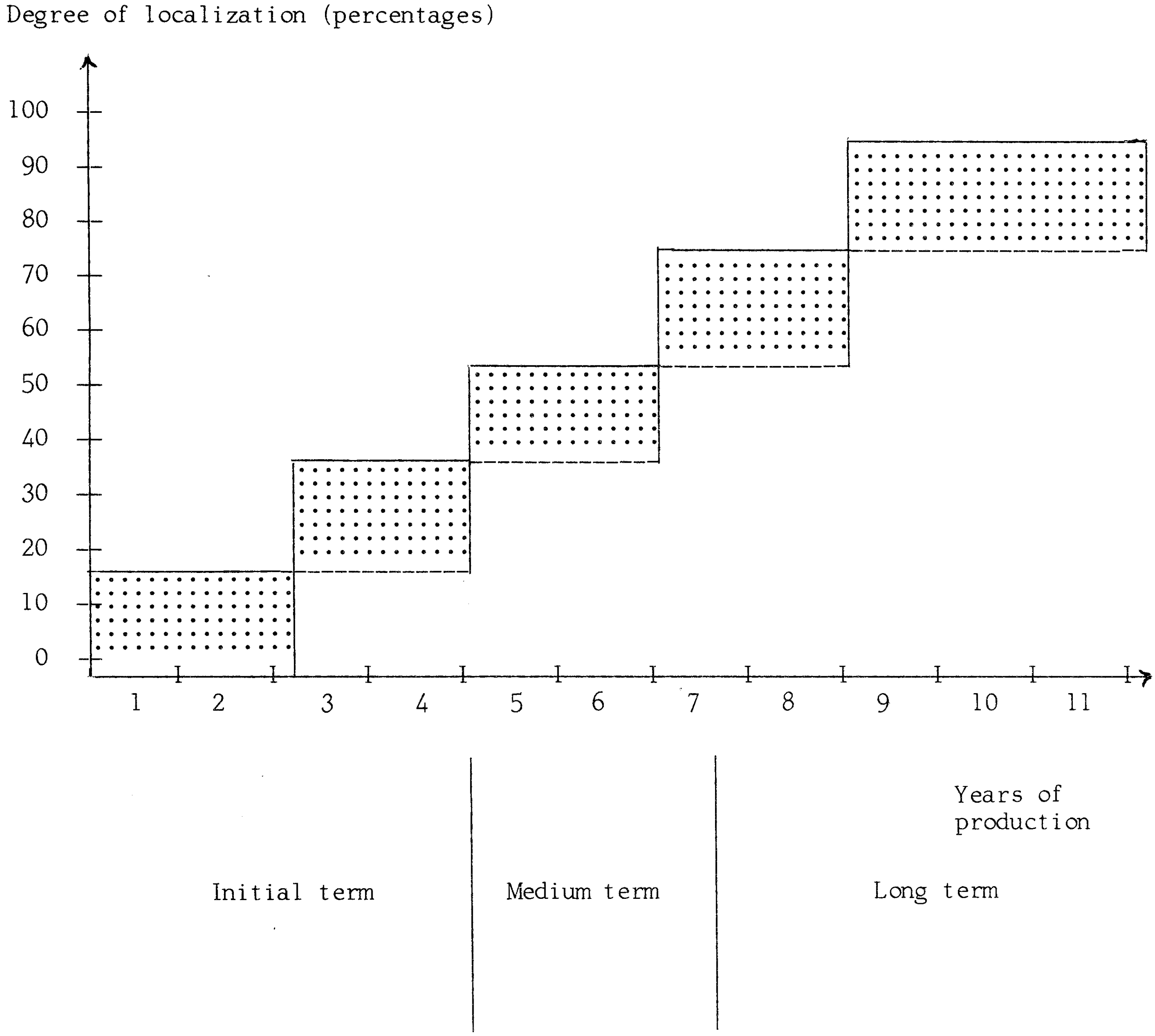
Source: Power Equipment Manufacturer.

Figure 2.1. Development of localization level for turbines



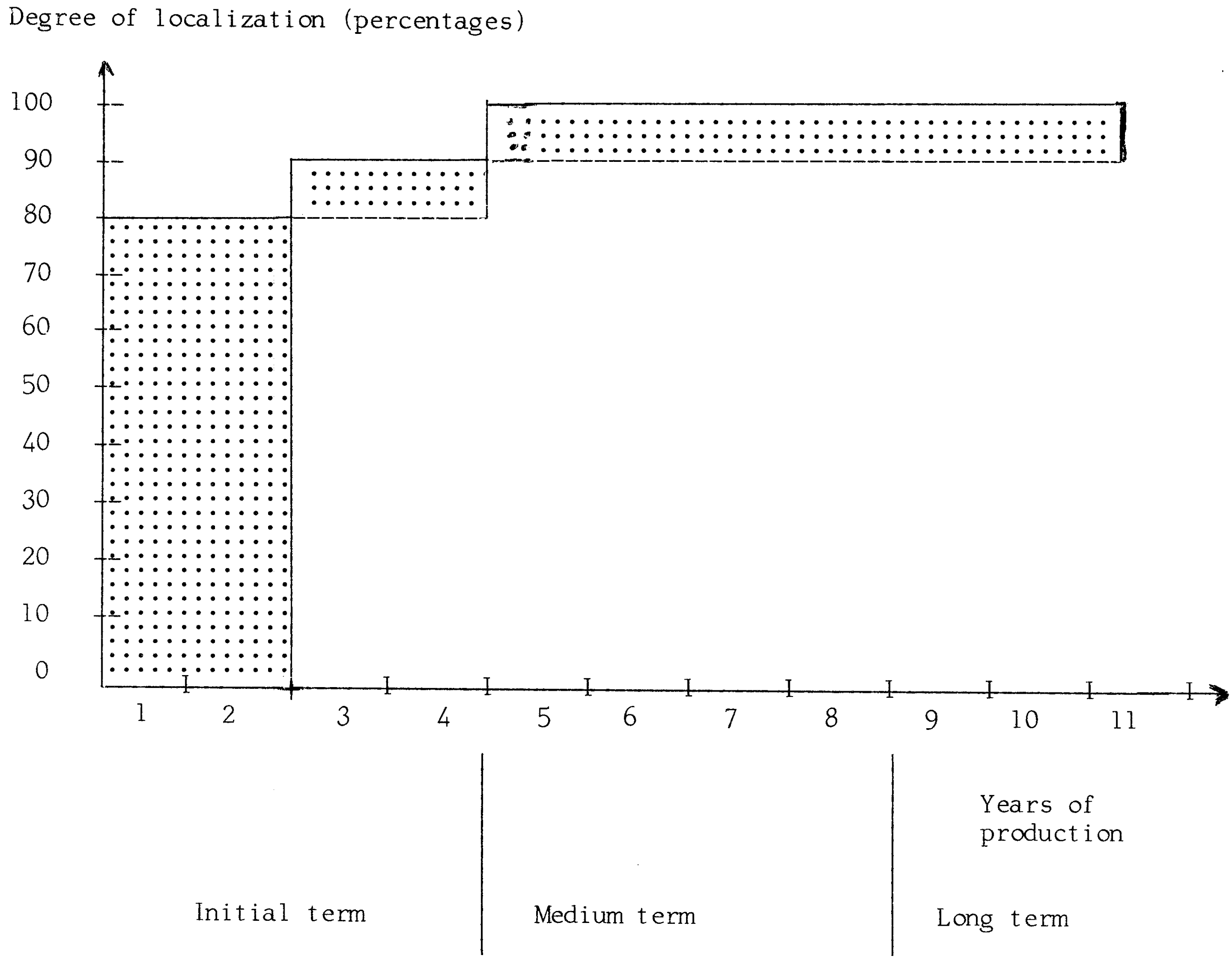
Source: Power Equipment Manufacturer.

Figure 2.2. Development of localization level for generators



Source: Power Equipment Manufacturer.

Figure 2.3. Development of localization level for thermal equipment



Source: Power Equipment Manufacturer.

CHAPTER 3

ORGANIZATION OF THE FACTORY

3.1 General

The organization of the factory during the pre-production (construction) phase and the production phase is described below.

3.2 Organization during the pre-production phase

Fig. 3.1 illustrates the organization proposed for the construction of the factory buildings, procurement of production equipment and materials, securement of technical assistance from international manufacturers, recruitment of personnel, initiation of training programmes and all other preparatory activities.

3.3 Organization during the production phase[1/]

As shown in figure 3.2, the factory will be organized into five divisions: planning, engineering, production, sales and contracts, and administration. The functions of each division will be as follows:

(a) Planning division

This division will be responsible for:

(i) Preparing flow charts and corresponding documents for equipping the various divisions with the essential systems and methods of organization; this includes, order flow (ordering documents, parts lists, drawings, working documents, etc.); control systems; job descriptions, etc.;

(ii) Planning plant capacity and production controls; this includes, strategic planning; budgeting; production planning, etc.;

(iii) Information systems; this includes, reporting system; organization of meetings, etc.

1/ Up to the end of the maturation period, an R & D function may be included in the engineering division. Thereafter, it may become a separate unit.

Figure 3.1. Organization chart during pre-production phase

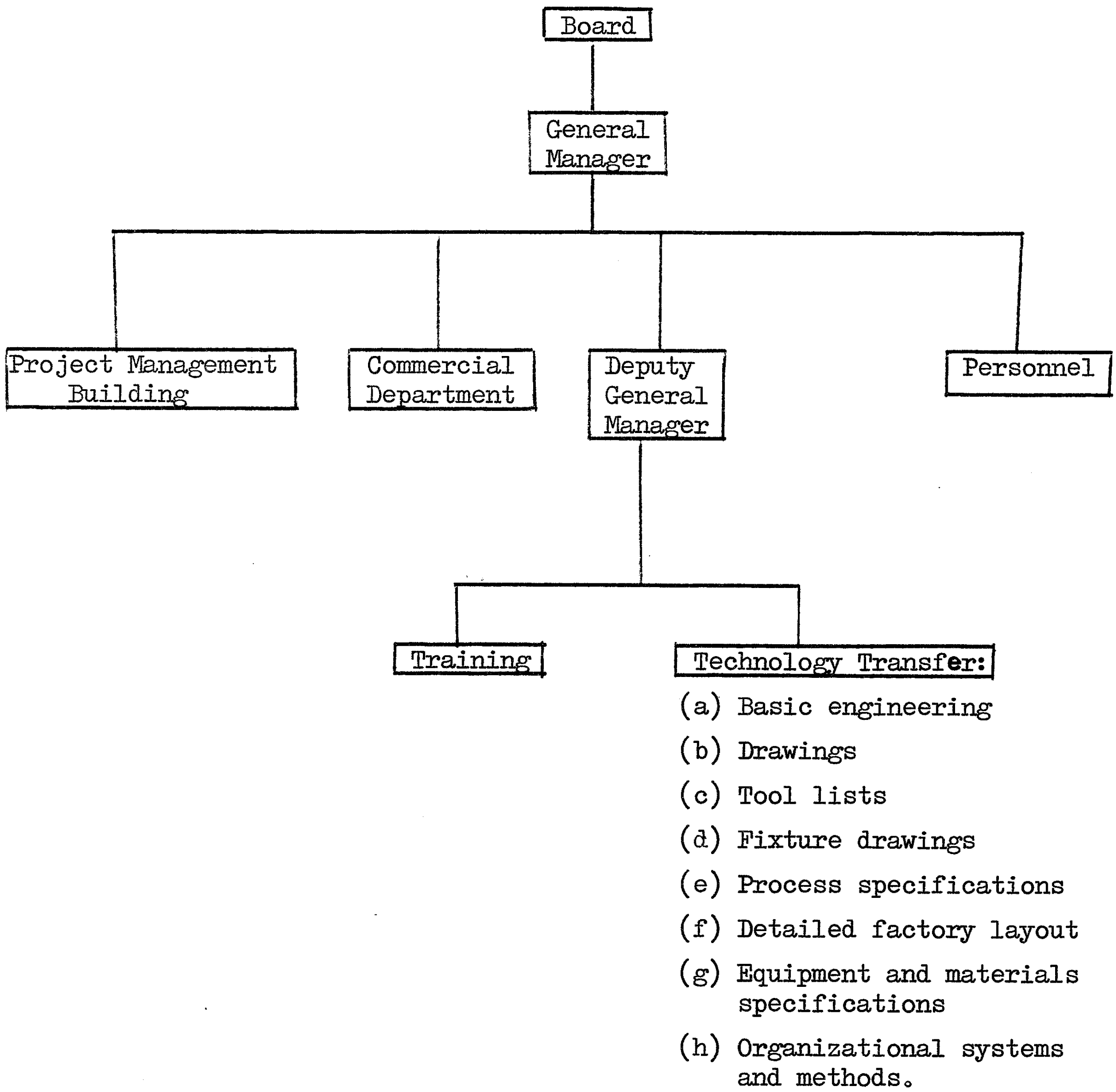
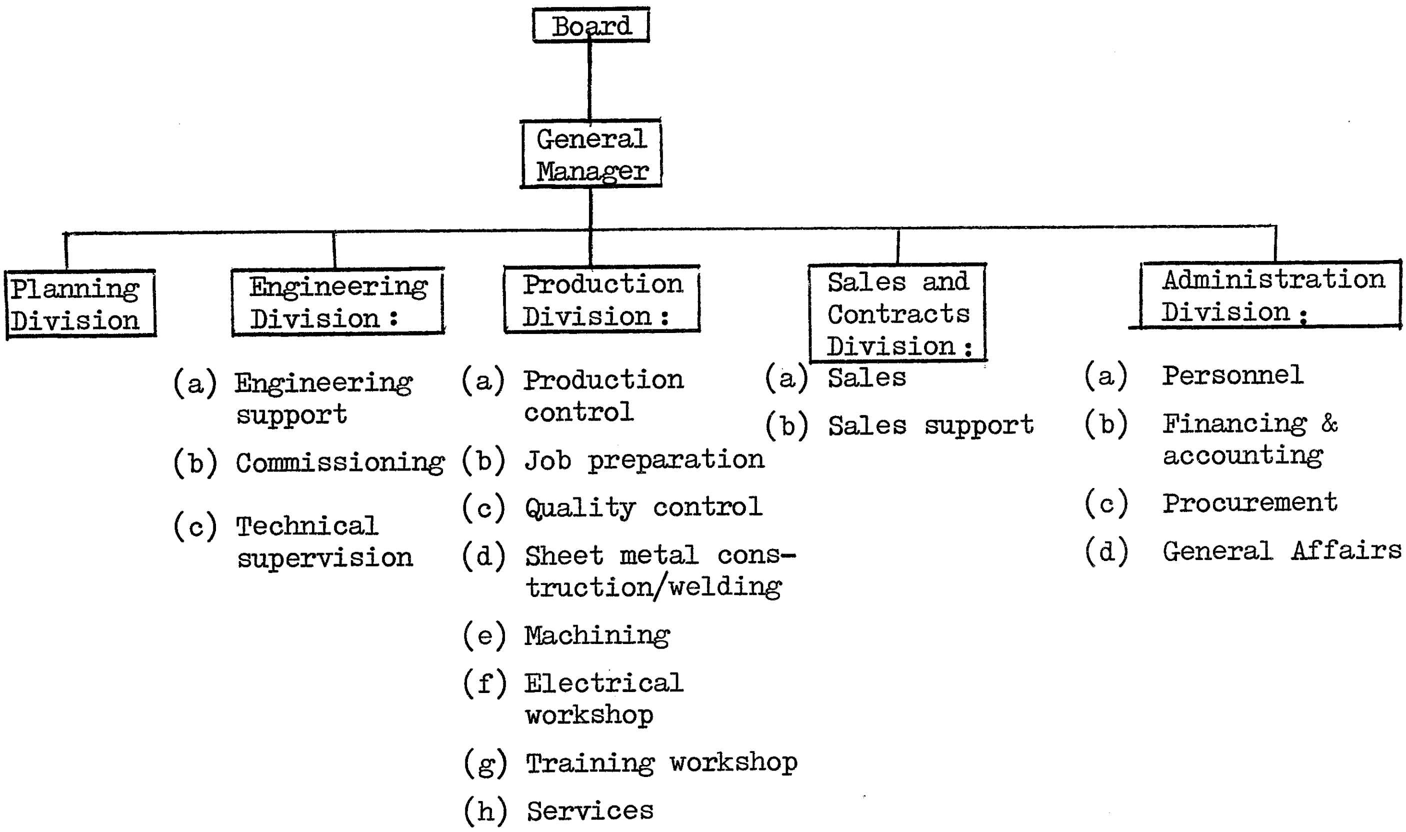


Figure 3.2. Organization chart during the production phase



(b) Engineering division

This division has five major functions:

(i) Engineering of products;
(ii) Adaptation to customers'demands;
(iii) Preparation of documents for the manufacture and development of products;

(iv) Supply of technical assistance to the buyers and users of the products;
(v) Testing of turbines and generators.

Since every order entails a high level of technical expertise and skills, it is essential to establish tangible measures to ensure that the engineering operations attain the required high standards.

(c) Production division

This division is responsible for:

(i) Manufacturing the products within the specified time and cost, and according to the established quality standards;

(ii) Maximizing the work load and productivity of the factory;

(iii) Adequate training of personnel.

To manufacture highly sophisticated produts such as turbines and generators, it is necessary to ensure that the workshops are efficiently organized, that the production control is adequate and that the work force is well-trained and motivated.

Efficient organization requires a clear division of responsibilities for the production process among various sections. These responsibilities are designated according to the nature of the tasks to be performed, the relationships between the various tasks and the optimum size of an organizational unit.

Production scheduling and control must guarantee punctual delivery, minimum process time, high workload and, consequently, low investment.

Adequate training emphasizes intensive training for foremen who will, in turn, train and supervise teams of workers. In addition to the OJT which the workers receive from their foremen, they must also be enrolled in a variety of training courses commensurate with the particular needs of their jobs. Because of its decisive impact on the outcome of the project, a separate section in the production division should be concerned exclusively with the training function.

In addition to the adequate training of workers, due attention should be paid to other ways of motivating the staff and achieving optimum production efficiency.

The following practices should be adopted:

(i) The workers should be kept well-informed about the factory, their workshops or offices and the production processes and should be encouraged to participate in solving problems that may arise.

(ii) Close co-operation between the maintenance group (included in the service section) and other production units should be established to carry out preventive maintenance to reduce expensive production interruptions and idle time of machines and equipment;

(iii) Drawings should be clear and operation plans easily understood; moreover, the required documents should always be available. Therefore, a well-organized documentation system should be established in the job-preparation section.

(d) Sales and contracts division

This division is responsible for:

(i) Providing technical assistance and counselling to clients and potential customers;

(ii) Profitable "technical" selling within the regional market, and possibly abroad later on;

(iii) Marketing;

(iv) Processing all paperwork relating to received orders.

For complex orders, senior salesmen should assume the responsibilities of project managers, to supervise and manage the entire transaction.

The "sales support" section is responsible, among other things relating to sales, for maintaining documentation, observing the portential market, and keeping close contacts with the engineering and production divisions. Salesmen for complex projects must be highly competent.

(e) Administrative division

This division is responsible for carrying out the services relating to:

(i) Personnel: recruitment, promotion, training, etc.;
(ii) Finance: accounting, cash-management, etc.;
(iii) Materials: procurement, etc.

CHAPTER 4

MANUFACTURING REQUIREMENTS

4.1 General

Manufacturing requirements[1/] comprise of the following:

(a) Land, buildings, roads, and utilities;
(b) Materials;
(c) Production and associated equipment;
(d) Personnel.

The values given below correspond with the full-production output level (3,000 MW/Year).

4.2 Land, buildings, roads and utilities

	Area (m2)
(a) Land, including reserve for possible expansion.	330,000
(b) Buildings	

(i) Manufacturing

Bay No.	Dimensions (m) Length	width	height	Crane hook (m)	Crane capacity (t)	Area (m2)
1	342 x	18 x	12	8	2 x 10) 2 x 20)	6,000
2	342 x	18 x	12	8	2 x 10)	6,000
3	342 x	24 x	16.5	11	2 x 10) 2 x 30) 2 x 150)	8,500
4	342 x	30 x	20	14	2 x 10) 1 x 20) 1 x 30) 3 x 60)	10,000
5	342 x	24 x	16.5	11	2 x 10) 1 x 20) 1 x 30) 3 x 60)	8,500
Total manufacturing buildings					39,00m^2	

1/ Including requirements for manufacturing thermal equipment: condesers, HP and IP heaters.

(ii) Ancillary services

Function	Area (m2)
Maintenance, repair, tool-making	1,260
Welding, pipe fitting, and stamping	11,790
Overspeed bunker and insulating block	9,500
Energy supply	1,230
Waste water treatment	650
Storage (enclosed)	1,860
Storage (outdoor)	22,500
Forwarding and crates	1,700
Internal transport	600
Fire fighting system	500
Tranining centre	2,750
Administration	3,600
Cateteria	1,850
Total ancillary services	59,790 m^2

A layout plan for the manufacturing facilities is shown in figure 4.1. The features of the plan include the following aspects: minimizing transport operations within the factory; ensuring that turbines and generators are manufactured in the same shop in order to utilize expensive key machines; and providing closed clean rooms which are necessary, for technological reasons, for the assembly of the rotor windings.

Bay 1 is designated for machining small- and medium-sized parts required in the manufacture of generators and turbines. In view of the relatively light weights and small dimensions of these parts, the height of the bay is 12 m and the crane capacities are 2 x 10 t and 2 x 20 t.

Bay 2 is mainly intended for producing stator bars, including insulation. At the end of the bay, pre-assembly of small parts takes place, and storage space is provided. The dimensions of the bay are the same as those of bay 1. However, a crane capacity of only 2 x 10 t is adequate.

Bay 3 is mainly intended for lamination production, stator assembly and testing areas, followed by packing large parts which are transported directly from the factory. This bay is 16.5 m high and, owing to the large weights of stators, crane capacities of 2 x 150 t, 2 x 30 t, and 2 0 10 t are required.

Figure 4.1. Layout plan for turbine/generator factory

<table>
<tr><td>1</td><td colspan="5">Machining
(Small to medium-sized parts)</td><td colspan="2">Machining
(Diverse machine components)</td></tr>
<tr><td rowspan="2">2</td><td colspan="3" rowspan="2">Stator bar manufacturing</td><td colspan="2" rowspan="2">Insulation shop</td><td colspan="2">Pre-assembly</td></tr>
<tr><td colspan="2">Intermediate store</td></tr>
<tr><td>3</td><td colspan="2">Assembly
pre-heaters and
coolers</td><td>Lamination
assembly</td><td colspan="2">Stator assembly,
stator testing</td><td rowspan="2">(Generators)
Assembly and
testing department
(Turbines)</td><td rowspan="2">Shipping</td></tr>
<tr><td>4</td><td colspan="4">Machining department for turbine and
generator conings</td><td>Cylinder
blading</td></tr>
<tr><td>5</td><td>Rotor
welding</td><td colspan="3">Rotor machining
department</td><td>Rotor
blading</td><td colspan="2">Rotor winding
assembly</td></tr>
</table>

Bay 4 contains the machines and equipment required for machining turbine and generator casings, as well as thermal equipment. Adjoining this is an area for inserting blades in turbine casings, followed by assembly and test areas. This bay is 20 m high. The capacities of the cranes are 3 x 60 t, 1 x 20 t, 1 x 30 t and 2 x 10 t.

Bay 5 contains shops for machining and welding shafts; equipment required for inserting the blades into the rotors; and a closed clean room for inserting windings into generators rotors.

To meet the needs of shaft welding and machining, this bay has the same height as bay 3. The crane capacities are 3 x 60 t, 1 x 30 t, 1 x 20 t, and 1 x 10 t.

(c) Roads

Approach roads or railway lines should be capable of carrying loads up to 300 tons.

(d) Utilities

Electricity supply line	4 to 6 kV
Annual electric power consumption	12,000 MWh
Annual fuel consumption	8,000 tons
Annual water consumption	365,000 m^3

4.3 Materials

The required materials and parts must meet very stringent quality standards in order to ensure the reliability and punctual delivery of the end product, and to minimize rejections during the manufacturing process and the extra costs associated with it. They include the following:

	Turbines	Generators
Grey cast iron	x	x
Cast steel	x	x
Cast aluminium	x	x
Electric steel sheet		x
Steel plate	x	x
Forgings	x	x
Rolled and drawn steel sections	x	x
Steel tubes	x	x
Special alloy tubes	x	x
Copper strip		x
Rolled and drawn copper rods		x
Insulating materials		x
Paint	x	x
Special alloy castings	x	x
Non-magnetic material		x

All through the production phase, certain components will have to be imported. (see tables 2.1 and 2.2)

4.4 Production and associated equipment

The most important machines and equipment are listed below:

(a) Machines and equipment for manufacturing turbines and thermal equipment

Drilling machines
Cylinder boring machines
Boring machines
Automatic boring machines
Boring and milling machines
Base-plates
Double-column plane-milling machines
Vertical lathes (NC and others)
Centre lathes
Shaft lathes
Items of auxiliary equipment
Deep drilling machine
Combined boring and milling machines
Special setting-up table
Base-plates
Roll bending machine
Sets of barring gear
Paint spray booths
Reversible lathe
Facing lathe
Thread rolling machine
Special machine to rotate workpieces
Vertical milling machines
Horizontal milling machines
Grinding machines
Jig drilling and milling machine
Equipment for detail fitting shop
Vertical annealing furnaces
Compressed-air plant
Special vertical furnace
Ammonia distribution system
Chamber furnace
Set of industion equipment
Set of welding equipment of rotors
Set of normal welding equipment
Argon installation
NC centres
NC copying system
Items of smithy equipment

Items for fitters' shop
Sheet-metal shop complete Items for surface treatment
Feed-heater assembly shop complete
Items for assembly of large units
Items for assembly of medium-size units
Items for construction of enclosures.

(b) Machines and equipment for manufacturing generators

Centre lathes
Vertical lathes
Grinding machines
Drilling machines
Jig boring machine
Multi-spindle drilling machine
Vertical milling machine
Automatic turntable
Washing unit
Universal milling machine
Vertical broaching machine
Planning machine
Slot drawing machine
Equipment for an assembly bay, including: 3 assembly base-plates
Vacuum furnace
Wedge insertion equipment
Hot press for coils
Brazing installation
H.V. test unit
Brazing and welding equipment
Taping machine
Stator rotating devices
Bar insulating machines
Hydraulic coil press
Continuous furnaces
Chamber furnace
Nitrogen treatment units
Shaping press
Impregnating plant
Tank for above
Micadur-compact installation
Ion exchanger
Silver transformers
Test transformers
Rotor slot milling machine
Double column plano-milling machines
Boring and milling machines
Planning machines
Horizontal milling machine

Chuck lathe
Winding machine
Double coiler
Hydraulic press
Pickling bath
Vacuum press
Set of X-ray equipment
Stretching bench
Leaching machine
Backing presses
Hydraulic press for coil limbs.

(c) Machines and equipment for welding, pipe fitting, and stamping

600-ton press
120-ton press
Wire grinding machine
Lacquering machine
Spot welding machine
Set submerged-arc automation equipment, including turnable and aligning pedestals
Roll
Sheet-metal and profile shears
Bending machines
Flame cutters
Sets welding equipment
Annealing furnaces
Sand-blasting unit
Paint spraying booth
Set X-ray equipment
Set ultrasonic equipment
Items of equipment for pipe-fitting shop.

(d) Testing equipment

Power supply equipment, including switching and measuring facilities
Power conversion and distribution system: consisting of:

- Thyristorized converters;
- Transformer and accessories;
- Rotary converters;
- Auxiliary works transformer;
- Crossbar selector, switches;
- Water cooling tower.

Test bays:

Drive motors;
Assembly rigs;
Bearing oil sealing and gas system;
Power distribution system;
Measuring and protective gear.

Overspeed test bay:

Balancing machine, including bed;
Drive (motor, gearing);
Systems for oil, cooling water ventilation;
Emergency power supply;
Control room;
Tunnel crane;
Transport trucks;
Drying oven.

Test beds for hydraulic equipment
Combined test rig for speed governments and monitors
Test bed for bearing pedestals
Test bed for main gear oil pumps
Test bed for servomotors
Test devices and tools.

4.5 Personnel

Category	No. of personnel
Division and department managers	12
Engineers	40
Draftsmen	32
Technicians	153
Foremen	50
Skilled workers	400
Unskilled workers	160
Clerical	359
Total 1/	1 211

1/ Almost 20% higher than suggested by international manufacturers.

The distribution of personnel among the various divisions in the factory is generally as follows:

General Manager's office

General Manager	1
Clerical	2
	3

Planning Division

Manager	1
Clerical	2
Engineers	4
	7

Engineering Division

Manager	2
Clerical	5
Engineers	22
Technicians	107
Draftsmen	32
	168

Production Division

Managers	5
Clerical	73
Engineers	6
Technicians	20
Foremen	50
Skilled workers	400
Unskilled workers	160
	714

Sales and Contracts Division

Manager	1
Clerical	10
Engineers	8
Technicians	31
	50

Administration Division

Managers	2
Clerical	267
	269

CHAPTER 5

THE TRANSFER OF TECHNOLOGY

5.1 General

The transfer of technology for highly sophisticated products, such as turbines ans generators, is the most significant factor governing the outcome of the project. The manner in which this problem is tackled and solved influences the medium- and long-term success of the local manufacturing operation to a far greater extent than the amount of invested capital. The preparations and means for transferring the required technology as well as its scope are presented in the following paragraphs.

5.2 Preparations and means for the transfer of technology

It is difficult at this stage to give an accurate definition of the scope of the technology that needs to be transferred. Such a definition could only be formulated in the process of a feasibility study, and should be based on the following factors:

(a) Specifications of the product(s) to be manufactured;
(b) Product mix;
(c) Annual production output;
(d) Build-up rate of the new industry;
(e) Prevailing local conditions: available skills, supporting industries, etc., in the country hosting the factory.

The process of transferring technology from an international manufacturer of power equipment to the regional industry is governed by contractual documents between the parties. The contracted licences must go beyond a simple right to copy the licencer's existing product designs; they should allow the regional industry in due course to achieve full independence.

5.3 Scope of required technology

The required technology covers a wide spectrum of activities, from the preparatory work which lays down plans for the pre-production (construction) and production phases, to the after-sale services provided by the regional industry to its clients (electricity authorities, manufacturing industries, etc.). It encompasses:

(a) Technical know-how for the product range, including specification of machines, technical software;

(b) Continuous flow of new R & D results achieved by the licencer;

(c) Know-how relating to production, installation, and after-sale services of the product range;

(d) Designing of production facilities, and specification of machine tools and equipment. All machines, equipment and tools must conform to international standards in order to avoid problems connected with the acquisition of spare parts or replacements for equipment;

(e) Documentation of the production processes and the production control systems;

(f) Operational procedures and systems required by the new factory, e.g. inventory, incoming inspection and quality control;

(g) Specialized support relating to sales, marketing and similar functions;

(h) Training;

(i) Establishment of R & D facilities.

5.4 Training

Training is a form of technology transfer. The manner in which it is planned and implemented influences the economic success of a manufacturing project to a considerable degree.

For a complex project, such as the one under consideration, intensive training efforts are made during the pre-production phase. During the production phase, the intensity of training efforts gradually decreases; however, it will never cease because training is a permanent feature of a manufacturing operation.

Training involves considerable investment in time and money and has, as such, a determental effect on the profitability of a project in the short-term. This outcome is unavoidable. However, training will ultimately prove to be a worthwhile investment.

The purpose of training is to provide personnel capable of carrying out the activities engaged in by the factory. Such tasks are related to the functions of the five divisions in the factory, namely: planning, engineering, production, sales and contracts, and administration. For every task that has to be performed, a corresponding set of job requirements should be established. The gap between locally available skills and job requirements determines the scope, intensity, duration and location of the training programmes.

In general, the licencer's facilities are used for training for particularly difficult tasks such as those performed by design engineers, production engineers and senior foremen. Some of the staff trained in this manner will eventually train the work force at the local factory. However, more often than not, the licencer is reluctant to send large numbers of his personnel abroad to train the local staff since the former are needed for his own operations.

A representative training programme for production personnel is presented in annex I.

CHAPTER 6

FINANCIAL ASPECTS

6.1 General

The financial analysis presented in this study is applicable to the full-production output level (3,000 MW/year). All values (costs, wages, prices, etc.) are given in 1979 constant prices, and must be regarded as approximate values.

The analysis is performed for two groups of countries categorized according to the average wage level and construction cost. Group I includes the oil exporting countries, whereas Group II consists of the non-oil exporting countries.

6.2 Factors of cost

(a) The cost of land and construction as well as wages are estimated in (US$) as shown below:

	Group I	Group II
Land	20/m^2 [1]	30/m^1 [1]
Buildings[2]		
Manufacturing bays (39,000 m^2)	1,100/m^2	825/m^2
Welding, pipe fitting and stamping workshop (11,790 m^2)	1,100/m^2	825/m^2
Overspeed bunker and insulating block (9,500 m^2)	460/m^2	350/m^2
Ancillary services, including outdoor storage (38,500 m^2)	310/m^2	234/m^2
Roads[3]	50/m^2	50/m^2

1/ This is double the cost given for the telephone exchange factory because for the turbine and generator factory the site must be close to highways, railroads, water and electric power networks.

2/ As specified in section 4.2, and including railroads inside the factory buildings.

3/ Within the site only.

Monthly wages[1]	Group I US$	Group II US$
Division and department manager	5,000	3,000
Engineer	4,000	2,500
Draftsman	1,800	1,250
Technician	1,800	1,250
Foreman	1,800	1,250
Skilled worker	1,200	850
Unskilled worker	600	425
Clerical	1,000	1,000

(b) The ex-factory 1979 prices of production equipment and materials are given below:

Production equipment	Cost in million US$
Turbine and generator manufacture, Including thermal equipment	109
Welding, pipe fitting and stamping	15
Overspeed pit	17
Auxiliary services	7
Total	148 million

Materials and semi-finished parts	Cost in million US$
Materials	86
Semi-finished parts	55
Total	141 million

(c) Royalty fees : 7.5[2] per cent of sales
(d) Selling price: 94 US$/kW[3]
(e) Maturation period: 13 years.

It is assumed that the build-up of production output and the distribution of the main costs during the maturation period are as follows:

1/ Wages include salaries and all fringe benefits.

2/ Consisting of 4 per cent pure royalty and 3.5 per cent for technical assistance.

3/ This is the price of the turbine, generator, control, and thermal equipment.

	Pre-production year				Production year								
	1	2	3	4	5	6	7	8	9	10	11	12	13
Production output (%)					10	20	30	40	50	60	70	80	100
Fixed investment (%)	20	20	30	30									
Cost of materials (%)					10	20	30	40	50	60	70	80	100
Wages (%)					70	70	70	80	80	80	100	100	100

6.3 Analysis and results

The financial analysis is carried out in annex II. The main results are presented in table 6.1. They indicate:

(a) The manufacture of turbines and generators, although economically viable, entails huge capital investment, a long pay-back period, and a moderate internal rate of return;

(b) The plant capacity ought to be higher than the 3,000 MW assumed in this study;

(c) The location of the factory does not seem to have a significant impact on the unit cost of production. This is attributed to the high share of material cost in the total cost of production.

The results obtained in this study must be regarded as broadly indicative due to the many uncertainties which were pointed out in this report. They should be substantiated by a detailed feasibility study.

Table 6.1. Decision matrix for turbines and generators with an annual output of 3000-MW

Item No.	Description	Group I	Group II
1.	Total fixed capital all equity basis (million US$)	331	307
2.	Total fixed capital, with long term loans (million US$)	368	341
	- Equity	184	171
	- Loan	184	170
3.	Working capital, assumed short borrowing (million US$)	67	66
4.	Number of persons employed	1 211	1 211
5.	Pay-back period	10	9
6.	Return on equity in 9 years of operation (%)	26	32
7.	Average undiscounted rate of return over 15 years period on total cash (% per annum)	9	12
8.	Internal rate of return (% per annum)	6	8
9.	Fixed capital per person employed (thousand US$)	273	254
10.	Unit cost of production (US$/kW)	78	76

Source: Joint ECWA/UNIDO Industry Division.

ANNEX I

A REPRESENTATIVE TRAINING PROGRAMME FOR PRODUCTION PERSONNEL

Training candidates are divided into five categories according to the level of education. These categories correspond to a set of job requirement levels as shown in table I.1

The job requirement levels and basic functions are explained in tables I.2 and I.3, respectively.

A possible training programme is shown in table I.4

Table I.1. Educational and job requirement levels of trainees

Education level	job requirement level					
	D	C	B	A	M I	M II
(a) Ability to read and write, plus some practical experience	x					
(b) Primary education, plus slight professional experience		x				
(c) High school (12 years):						
(i) without additional training			x			
(ii) with additional training (technical/administrative)						
(iii) with additional training (commercial)						
(d) Technical institute/vocational or trade school				x	x	
(e) University					x	x

Source : Power equipment manufacturer.

Table I.2. Description of job requirement levels

Job requirement level	Explanation
M II	Qualified staff with managerial experience who after spending some time as assistant to the licensor's staff are capable of leading a fairly large organizational unit.
M I	Qualified staff with professional experience who are capable of performing managerial duties.
A	Future employees who, after a period of training and a period of application, are capable of performing special duties.
B	Future employees who, after a period of training of at least 1 year, are capable of performing tasks demanding a high standard of knowledge and experience.
C	Future employees who, after a period of training lasting between 1 and 5 months, are capable of performing tasks demanding a medium standard.
D	Future employees who, after a brief introductory period, are able to perform simpler tasks.
IN	Qualified staff with professional background and specialized training who are capable of training other workers.

Source: Power Equipment Manufacturer.

Table I.3. Basic Functions of job requirement levels

Job requirement level	Basic function	
IN	Training instructor	
M II	Manager grade II: - Assistant manager - Section manager	
M I	Manager grade I: - Foreman - Group leader	
A	Skilled workers: marker, setter, quality control, inspector, maintenance, tool and equipment designer, job preparation, production control.	
B	Machine tools	: Machinist, operator.
	Mechanics	: Detail assembler, machine fitter, mechanic.
	Fitters	: Assembly fitter, pipe fitter, industrial welder.
	Electricity	: Electrician, winder, electrical assembler, telecom. technician.
	Others	: Galvanizer, smith, carpenter.
C	Turner, milling cutter, driller, planer, stamper, trinder, wireman, painter, crane driver, truck driver, storeman, workshop clerk.	
D	Unskilled worker	

Source: Power Equipment Manufacturer.

Table I.4. A sample training programme

Training stages		1	2	3	4	5
Management training II	Advance of aspects of management training I. Basis: Management techniques System techniques applied with assistance of a supervisor provided by the licenser.			MII		MII
Management training I	Basis: Management fundamentals: Planning, organizing, setting of tasks, control applied with assistance of a supervisor provided by the licenser.			MI MI	MI MII	MI
Speciali-zation	Training for special functions: Operating/scheduling Production control Quality control			A	A	
Advanced training	Advanced and applied basic OJT under the supervision of qualified local instructors.			MI		MI MII
Basic training III	Enlarged basic training: Machine tools Machinery/buildings Fitter Electrical specialist			B		
Basic training II	Practice Basic training on machine tools General training or specialization on one machine type		C			
Basic training I	Practice Basic professional skill (e.g. polishing, drilling, cutting of windings, measuring, etc.)				A MI MII	MI MII
Intro-duction	Environmental factors of the factory compulsory for all staff prior to entering thefactory.	D				
		1	2	3	4	5
		Educational level				

Source: Power Equipment Manufacturer.

ANNEX II

FINANCIAL ANALYSIS FOR TURBINES AND GENERATORS

Table II.1. Fixed capital cost for turbines and generators with an annual output of 3000 MW
(In thousand US dollars)

	Element of costs	Group I	Group II
A.	Land and site development		
A1	Land	6 600	6 600
A2	Grading ($ 2/m^2)	660	660
A3	Fencing	100	100
A4	Roads	300	300
A5	Drainage, sewage, street lighting	800	800
A6	Temporary structure to supervise construction	900	540
A7	Contingencies (10 per cent of items A2 to A6)	276	240
	TOTAL A	9 636	9 240
B.	Building and civil works		
B1	Buildings	72 174	54 236
B2	Contingencies (10 per cent of B1)	7 217	5 424
	TOTAL B	79 391	59 660
C.	Plant and equipment		
C1	Production equipment	148 000	148 000
C2	Freight, insurance, transport (7 per cent of C1)	10 360	10 360
C3	Erection and commissioning (10 per cent of C1)	14 800	14 800
C4	Utilities and service equipment	4 000	2 000
C5	Contingencies (10 per cent of items C1 to C4)	17 716	17 516
	TOTAL C	194 876	192 676
D.	Project engineering and pre-operation costs		
D1	Project engineering (3 per cent of items A2 to C5)	8 319	7 649
D2	Project establishment	12 000	11 000
D3	Royalties (7.5 per cent of annual sales discounted at 9 per cent for the first 5 years of production)	22 614	22 614
D4	Interest during construction period (on US$ 184,000/170,000 at 9 per cent)	33 077	30 662
D5	Contingencies (10 per cent of items D1 to D4)	7 601	7 193
	TOTAL D	83 611	79 118
	GRAND TOTAL A to D	367 520	340 694
E.	Financing		
E1	Equity	184 000 000	171 000 000
E2	Loan	184 000 000	170 000 000

Source: Joint ECWA/UNIDO Industry Division.

Table II.2. Annual cost of production for turbines and generators with an annual output of 3000 MW
(In thousand US dollars)

Element of cost	Group I	Group II
1. Input materials		
a. Ex-factory	141 000	141 000
b. Freight, insurance, transport (7 per cent of 1a)	9 870	9 870
2. Wages	19 044	14 436
3. Electricity (5 cents/kWh)	600	600
4. Water (30 cents/m^3)	110	110
5. Fuel	800	1 600
6. Maintenance supplies for plant and equipment (5 per cent of item C, table 2.1)	9 744	9 634
7. Maintenance supplies for civil works (3 per cent of items A2 to A5 plus B table 2.1)	2 438	1 846
8. Establishment cost (2.5 per cent of value of sales)	7 050	7 050
9. Depreciation and amortization		
a. Plant and equipment (10 per cent of item C, table 2.1)	19 488	19 268
b. Civil works (3 per cent of items A2 to A5 plus B, table 2.1)	2 438	1 846
c. Amortization of projecting costs (over 15 years)	5 574	5 275
10. Interest on long-term loan (9 per cent on half the loan)	8 280	7 650
11. Interest on working capital (10 per cent)	6 659	6 552
12. Contingencies (5 per cent of items 3 to 8 plus 10 and 11)	1 784	1 752
Total cost of production	234 879	228 489
13. Unit cost of production (US $/kW)	78	76

Source: Joint ECWA/UNIDO Industry Division

Table II.3. Estimated working capital for turbines and generators with annual output of 3000 MW
(In thousand US dollars)

Element of cost	Basis of provision	Group I	Group II
1. Wages[a/]	1 month	1 587	1 203
2. Materials[b/]	4 months	50 290	50 290
3. Establishment cost[c/]	1 month	2 419	2 374
4. Finished inventory[d/]	1/2 month	8 289	8 075
5. Bills receivable[e/]	1 month	16 578	16 150
Total		79 163	78 092
6. Less bills payable[f/]	1 month	12 573	12 573
Average working capital		66 590	65 519

Source: Joint ECWA/UNIDO Industry Division.

a/ Item 2 table II.2

b/ Item 1 table II.2

c/ Items 3 to 8 plus 10 table II.2

d/ Items 1 to 8 plus 10 table II.2

e/ Items 1 to 8 plus 10 table II.2

f/ Items 1 table II.2 .

Table II.4. Cash flow statement for turbines and generators, with an annual output of 3000 MW in group I
(In thousand US dollars)

Year from start of operation	(4)	(3)	(2)	(1)	1	2	3	4	5	6	7
A. Fixed investment	(66 227)	(66 227)	(99 340)	(99 340)							
		(331 135)									
B. Cash outflow on:											
1. Materials					15 087	30 174	45 261	60 348	75 435	90 522	105 609
2. Wages and salaries					13 331	13 331	13 331	15 235	15 235	15 235	19 044
3. Utilities					1 600	1 600	2 400	2 400	3 200	3 200	4 000
4. Maintenance supplies for plant and equipment					9 744	9 744	9 744	9 744	9 744	9 744	9 744
5. Maintenance supplies for civil works					2 438	2 438	2 438	2 438	2 438	2 438	2 438
6. Running cost					1 410	2 115	2 820	3 525	4 230	4 935	5 640
7. Interest on working capital					1 332	1 998	2 664	3 330	3 995	4 661	5 327
8. Contingencies (5 per cent of items 3 to 7)					826	895	1 003	1 072	1 180	1 249	1 357
TOTAL B					45 768	62 295	79 661	98 092	115 457	131 984	153 159
C. Inflow through sales					28 200	56 400	84 600	112 800	141 000	169 200	197 400
D. Salvage value					-	-	-	-	-	-	-
E. (Outflow)/Inflow	(66 227)	(66 227)	(99 340)	(99 340)	(17 568)	(5 895)	4 939	14 708	25 543	37 216	44 241
		(331 135)									

(Continued)

Table II.4. (Continued)

Year from start of operation	8	9	10	11	12	13	14	15
A. Fixed investment								
B. Cash outflow on:								
1. Materials	120 696	150 870	150 870	150 870	150 870	150 870	150 870	150 870
2. Wages and salaries	19 044	19 044	19 044	19 044	19 044	19 044	19 044	19 044
3. Utilities	4 000	4 000	4 000	4 000	4 000	4 000	4 000	4 000
4. Maintenance supplies for plant and equipment	9 744	9 744	9 744	9 744	9 744	9 744	9 744	9 744
5. Maintenance supplies for civil works	2 438	2 438	2 438	2 438	2 438	2 438	2 438	2 438
6. Running cost	6 345	7 050	7 050	7 050	7 050	7 050	7 050	7 050
7. Interest on working capital	5 993	6 659	6 659	6 659	6 659	6 659	6 659	6 659
8. Contingencies (5 per cent of items 3 to 7)	1 426	1 495	1 495	1 495	1 495	1 495	1 495	1 495
TOTAL B	169 686	201 300	201 300	201 300	201 300	201 300	201 300	201 300
C. Inflow through sales	225 600	282 000	282 000	282 000	282 000	282 000	282 000	282 000
D. Salvage value	-	-	-	-	-	-	-	51 467
E. (Outflow)/Inflow	55 914	80 700	80 700	80 700	80 700	80 700	80 700	132 167

Source: Joint ECWA/UNIDO Industry Division .

Table II.5. Cash flow statement for turbines and generators, with an annual output of 3,000 MW in group II
(In thousand US dollars)

Year from start of operation	(4)	(3)	(2)	(1)	1	2	3	4	5	6	7
A. Fixed investment	(61 393)	(61 393)	(92 090)	(92 090)							
	(306 966)										
B. Cash outflow on:											
1. Materials					15 087	30 174	45 261	60 348	75 435	90 522	105 609
2. Wages and salaries					10 105	10 105	10 105	11 549	11 549	11 549	14 436
3. Utilities					800	800	1 200	1 200	1 600	1 600	2 000
4. Maintenance supplies for plant and equipment					9 634	9 634	9 634	9 634	9 634	9 634	9 634
5. Maintenance supplies for civil works					1 846	1 846	1 846	1 846	1 846	1 846	1 846
6. Running cost					1 410	2 115	2 820	3 525	4 230	4 935	5 640
7. Interest on working capital					1 310	1 966	2 621	3 276	3 931	4 586	5 242
8. Contingencies (5 per cent of items 3 to 7)					750	818	906	974	1 062	1 130	1 218
TOTAL B					40 942	57 458	74 393	92 352	109 287	125 802	145 625
C. Inflow through sales					28 200	56 400	84 600	112 800	141 000	169 200	197 400
D. Salvage value					-	-	-	-	-	-	-
E. (Outflow)/Inflow	(61 393)	(61 393)	(92 090)	(92 090)	(12 742)	(1 058)	10 207	20 448	31 713	43 398	51 775
	(306 966)										

(Continued)

Table II.5. (Continued)

Year from start of operation	8	9	10	11	12	13	14	15
A. Fixed investment								
B. Cash outflow on:								
1. Materials	120 696	150 870	150 870	150 870	150 870	150 870	150 870	150 870
2. Wages and salaries	14 436	14 436	14 436	14 436	14 436	14 436	14 436	14 436
3. Utilities	2 000	2 000	2 000	2 000	2 000	2 000	2 000	2 000
4. Maintenance supplies for plant and equipment	9 634	9 634	9 634	9 634	9 634	9 634	9 634	9 634
5. Maintenance supplies for civil works	1 846	1 846	1 846	1 846	1 846	1 846	1 846	1 846
6. Running cost	6 345	7 050	7 050	7 050	7 050	7 050	7 050	7 050
7. Interest on working capital	5 897	6 552	6 552	6 552	6 552	6 552	6 552	6 552
8. Contingencies (5 per cent of items 3 to 7)	1 286	1 354	1 354	1 354	1 354	1 354	1 354	1 354
TOTAL B	162 140	193 742	193 742	193 742	193 742	193 742	193 742	193 742
C. Inflow through sales	225 600	282 000	282 000	282 000	282 000	282 000	282 000	282 000
D. Salvage value	-	-	-	-	-	-	-	40 616
E. (Outflow)/Inflow	63 460	88 258	88 258	88 258	88 258	88 258	88 258	1128 874

Source: Joint ECWA/UNIDO Industry Division

Table II.6 Discounted cash flow and rate of return for turbines and generators, with an annual output of 3000 MW in group I
(In thousand US dollars and percentages)

	Year from start of operation	Undiscounted amount	Compounded/Discounted value at 6 per cent Factor	at 6 per cent Value	at 7 per cent Factor	at 7 per cent Value
A. Outflows	(4)	(66 227)	1.2625	(83 611)	1.3108	(86 810)
	(3)	(66 227)	1.1910	(78 876)	1.2250	(81 128)
	(2)	(99 340)	1.1236	(111 618)	1.1449	(113 734)
	(1)	(99 340)	1.0600	(105 300)	1.0700	(106 294)
TOTAL A	0	(331 135)		(379 406)		387 966
B. Net inflows	1	(17 568)	0.9400	(16 514)	0.9300	(16 338)
	2	(5 895)	0.8836	(5 209)	0.8649	(5 099)
	3	4 939	0.83058	4 102	0.80436	3 973
	4	14 708	0.78075	15 339	0.74805	14 697
	5	25 543	0.7339	18 746	0.69569	17 770
	6	37 216	0.68987	25 674	0.64699	24 078
	7	44 241	0.64848	28 689	0.6017	26 620
	8	55 914	0.60957	34 083	0.55958	31 288
	9	80 700	0.57299	46 240	0.52041	41 997
	10	80 700	0.53862	4 367	0.48398	39 057
	11	80 700	0.50630	40 858	0.4501	36 323
	12	80 700	0.47592	38 407	0.4186	33 781
	13	80 700	0.44737	36 103	0.38929	31 416
	14	80 700	0.42052	33 936	0.36204	29 217
	15	132 167	0.39529	52 244	0.3367	44 501
TOTAL B		775 565		396 165		353 281

Average undiscounted rate of return: (per cent) $\frac{775\ 465 - 331\ 135}{331\ 135 \times 15} \times 100 = 8.9$

Internal rate of return: (per cent) $= 6 + \frac{(396\ 165 - 379\ 406) \times (7-6)}{(396\ 165 - 379\ 406) + (387\ 966 - 353\ 281)} \times 100 = 6.3$

Payback period = 10 years.

Source: Joint ECWA/UNIDO Industry Division.

Table II.7. Discounted cash flow and rate of return for turbines and generators, with an annual output of 3000 MW in group II
(In thousand US dollars and percentages)

	Year from start of operation	Undiscounted amount	Compounded/Discounted value at 7 per cent Factor	Value	at 8 per cent Factor	Value
A. Outflows	(4)	(61 393)	1.3108	(80 474)	1.3605	(83 525)
	(3)	(61 393)	1.2250	(75 206)	1.2597	(77 337)
	(2)	(92 090)	1.1449	(105 434)	1.1664	(107 414)
	(1)	(92 090)	1.0700	(98 536)	1.0800	(99 457)
TOTAL A	0	(306 966)		(359 650)		(367 733)
B. Net inflows	1	(12 742)	0.9300	(11 850)	0.9200	(11 723)
	2	(1 058)	0.8649	(915)	0.8464	(895)
	3	10 207	0.80436	8 210	0.77869	7 948
	4	20 448	0.74805	15 296	0.71639	14 649
	5	31 713	0.69569	22 062	0.65908	20 901
	6	43 398	0.64699	28 078	0.60636	26 315
	7	51 775	0.60170	31 153	0.55785	28 883
	8	63 460	0.55958	35 511	0.51322	32 569
	9	88 258	0.52041	45 930	0.47216	41 672
	10	88 258	0.48398	42 715	0.43439	38 383
	11	88 258	0.45010	39 725	0.39964	35 271
	12	88 258	0.41860	36 945	0.36767	32 449
	13	88 258	0.38929	34 358	0.33825	29 853
	14	88 258	0.36204	31 953	0.31119	27 465
	15	128 874	0.3367	43 392	0.28630	36 897
TOTAL B		865 623		402 563		360 637

Average undiscounted rate of return (per cent): $\frac{865\ 623 - 306\ 966}{306\ 966 \times 15} \times 100 = 12.1$

Internal rate of return (per cent) $= 7 + \frac{(402\ 563 - 359\ 650) \times (8 - 7)}{(402\ 563 - 359\ 650) + (367\ 733 - 360\ 637)} \times 100 = 7.8$

Payback period = 9 years.

Source: Joint ECWA/UNIDO Industry Division.

VOLUME II

PART 3

PRE-FEASIBILITY STUDY ON TRANSFORMERS

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LIST OF ABREVIATIONS

ft	foot
Hz	Herz
kV	Kilo volt
kVA	Kilo volt-ampere
m	meter
m^2	square meter
m^3	cubic meter
MVA	Mega volt-ampere
MW	Mega watt
MWh	Mega watt-hour
OJT	On the job training
OLTC	onload tap-changer
PDRY	People's Democratic Republic of Yemen
UAE	United Arab Emirates
US	United States
YAR	Yemen Arab Republic
Yr	Year

INTRODUCTION

The pre-feasibility study presented in this volume pertains to the manufacture of transformers.

The study is based on the results and conclusions reached in part 1 of this volume, which analysed the basic economic and technological aspects relating to electric power equipment, and on the manufacturing data provided by BBC Brown Boveri and company of Switzerland. General Electric of the USA provided important inputs for this study. The data on local wages, cost of construction, etc. were supplied by leading consulting firms and construction companies in the ECWA region. Other inputs necessary for conducting the study were generated by the Joint ECWA/UNIDO Industry Division.

The scope of this study comprises:

1. Project parameters: characteristics of the products, plant capacity, the production processes, maturation period, development of local added value, etc.

2. Structure of the factory's organization.

3. The type of technology needed, and the means for acquiring it. Special emphasis is placed on the training function.

4. Manufacturing requirements: facilities, machinery, materials and personnel.

5. Financial implications, including size of investment, payback period and rate of return.

It should be emphasized at this point that the results obtained in this study are broadly indicative, and must be substantiated by a detailed feasibility study where many parameters, which are not well defined at this stage, could be completely specified, e.g. location of the factory, precise specifications of the products, product mix, plant capacity, etc.

CHAPTER I

BACKGROUND

1.1 General

The information and conclusions presented in this chapter are based on part 1 of this volume, which provides a basic background for this study. It encompasses the following topics:

(a) The projected size of the market for transformers;
(b The types of transformers selected for this study;
(c) Existing transformer and supporting industries.

1.2 The projected market for transformers

The size of the market for transformers in the ECWA region for the period 1980-2000 is projected as follows:

Table 1.1. Projected demand for transformers' capacity (MVA) in ECWA region, 1980-2000 a/

	Average annual increase (MVA)			
	1981-1985	1986-1990	1991-1995	1996-2000
Total ECWA region of which:	14 196	26 206	27 312	41 451
Distribution transformers	3 165	5 730	6 041	9 220
Medium power transformers	4 762	8 520	9 041	13 853
Large power transformers	6 269	11 956	12 230	18 378

a/ See tables 2.21, 2.25, 2.26 vol.I, of this report, for distribution, medium-power and large-power transformers respectively.

Source: Joint ECWA/UNIDO Industry Division, reproduced from table 2.21, part 1 of volume II.

1.3 The selected products

The selection of transformers for regional manufacture if based on economic and technological considerations:

(a) As shown above, the regional market, even now, can absorb the outputs of viable distribution, medium-power and large-power transformer factories corresponding to a minimum of 3,000 MVA[1/] per year, per transformer category. On the othe hand, none of the national markets for distribution or medium-power transformers can absorb the outputs of such plants at any time during the projection period (1980-2000).

The data indicate that for large-power transformers the markets of Egypt, Iraq and Saudi Arabia can individually support national industries of this size during the next decade. Since large-power transformers, relative to other categories, require the highest level of manufacturing technology and skills, and distribution and medium-power transformers are geared for regional manufacture, it seems logical to manufacture this category on a regional basis as well;

(b) Transformer technology has been stable and the possibility of the manufacturing process becoming obsolete is very remote. Future research will concentrate on the development of better insulation and non-magnetic materials and on producing larger size units;

(c) The relative cost of transformers in the electric power system is second only to turbines and generators, if boilers and cables and wires, which are normally procured from specialized manufacturers, are excluded;

(d) The level of technology required for manufacturing transformers is proportionate to transformer size. For distribution transformers the region possesses basic manufacturing skills and infrastructure. This technological base can be developed to a level compatible with the requirements of larger transformer size.

The transformer categories proposed in this study are based on manufacturing considerations. From an operational point of view, their range covers the envisaged requirements of future power networks, from very small distribution transformers to large-power transformers compatible with future large generating plants and high transmission voltages.

1/ This figure was supplied by international manufacturers based on their past experiences in other countries. It can only be considered as an approximate figure at this stage because it depends on many parameters which are not, as yet, well defined and which will be specified in a detailed feasibility study. They include product mix, location of the factory, etc.

A minimum number of standard sizes must be adopted by the regional industry within each category. This would make the manufacturing operation more economical (fewer designs, less inventory, etc.), and enhance standardization of equipment in the region's power systems.

1.4 Existing transformer and supporting industries

Distribution and possibly some medium-power transformers are now manufactured on a national basis,1/ at least in Egypt and Iraq. The information available is inadequate in regard to actual sizes produced, production output, capacity of the plants, and future plans. Large-power transformers are not manufactured in the region.

Regarding supporting industries capable of supplying needed materials and components (steel sheets, plates, and tubes; copper strips and rods; insulating materials; non-magnetic materials; etc.), it is believed that some existing industries, most likely in Egypt, can cater for the needs of distribution transformers. However, it is doubtful that those industries can at present provide the more stringent quality materials needed for manufacturing larger transformer sizes.

An assessment of existing transformer and supporting industries will have to be made in subsequent feasibility studies in order to determine the feasibility of utilizing existing transformer factories and to develop the necessary industrial infrastructure.

1/ Although those industries have conceived the plan of exporting part of their outputs to other ECWA countries, they have not formulated concrete measures for that purpose.

CHAPTER 2

DEFINITION OF THE PROJECT

2.1 General

The topics analysed in this chapter are:

(a) Features of the products;
(b) Separate manufacture of transformers by size range;
(c) Plant capacity;
(d) The production processes;
(e) The maturation period;
(f) Development of the localization level;
(g) Manufacturing linkages with other products.

2.2 Features of the products

The data used in this study relating to manufacturing requirements, prices, costs, etc. are based on the following typical products:

(a) 20 kV, up to 1.25 or 6 MVA, without on-load regulation;
(b) 60 kV, up to 15 or 40 MVA, with on-load regulation;
(c) 130 kV, up to 75 MVA, with on-load regulation;
(d) 220 kV, up to 200 MVA, with on-load regulation.

Depending on the product mix which will be determined in the feasibility study, certain parameters such as material cost, selling prices, etc. will deviate from those given in this report. However, for the purpose of this study, the above models can be regarded as representative of the proposed product range given in section 1.2.

2.3 Separate manufacture of transformers by size range

The classification of transformers into three size ranges-distribution (0.25-1.25 MVA), medium-power (6-40 MVA), and large-power (75-200 MVA) - represents an expedient subdivision between individual factories, each catering for its particular range. The reasons for suggesting separate factories are:

(a) Each transformer category calls for a distinct level of design capability, which becomes higher as transformer size becomes larger;

(b) Unlike larger size transformers, distribution transformers can be serially produced. The power equipment industry has developed some automatic manufacturing techniques, e.g. aluminium foil windings with dry type insulation coated with epoxy resin and manufactured with the help of automatic winding and impregnating machines, etc.

The establishment of separate transformer factories does not exclude the possibility of developing centralized facilities in one factory to cater for the needs of all factories. Such an approach would be economically attractive in regard to certain transformer parts, e.g. finished laminations, condenser bushings, etc.

2.4 Plant capacity

The capacities of the factories under consideration are:

Transformer category	Plant capacity
Distribution 0.25-1.25 MVA	6,000 MVA
Medium-power 6-40 MVA	6,000 MVA
Large-power 75-200 MVA	10,000 MVA

The above plant capacities are substantially greater than the minimum viable plant capacity (about 3,000 MVA),1/ but will be less than the capacity required by the regional market when the factories attain maturation about the beginning of the next decade. Towards the end of the projection period, the production capacity will have to be increased by at least 50 per cent, either by expanding established factories or by setting-up new ones.

2.5 The production processes

The various stages in the production of a transformer are:

(a) Core assembly;
(b) Coil winding;
(c) Core and coil assembly and connections;
(d) Moisture removal by heat and vacuum treatment;
(e) Fabrication of tanks and radiators;
(f) Tanking and oil filling;
(g) Electrical testing;

Distribution, medium-power and large-power transformers undergo nearly similar stages to those mentioned above. However, the manufacture of high voltage large-size transformers requires expertise and skills in quality control, processing, and high voltage testing. For distribution transformers, electrical testing is the major operation requiring specialized skills.

The key to the success of the entire manufacturing process is the strict observance of cleanliness and careful handling of electrical coils and insulation during winding and assembly so that the equipment operates satisfactorily under high voltage.

1/ As stated by leading international manufacturers.

The moisture removal under heat and vacuum follows a strictly predetermined time cycle (about 10 to 12 days). The satisfactory operation of the transformer and its durability greatly depend on this step and on the quality of oil which is used for the first filling.

The fabrication of tanks and radiators is mainly done at the factory; special metal working facilities are required. The quality of welding must be of a high standard. The tanks and radiators are pressure tested to ensure leak-proofness. The radiators are pressed to the required shape from cold drawn steel sheets and are then welded face-to-face by hydrogen welding of the seam.

Two essential attachments to medium-and large-power transformers are "onload tap-changer" (OLTC) and condenser bushings. These are special products which can be attained from specialized suppliers. The regional industry could manufacture those products in the large-power transformer factory to cater for both large-and medium-power transformers. The manufacture of OLTC requires a different technology from that of a transformer as it contains a large number of small and precision components which are put together more like a switch gear.

The manufacture of condenser bushings is another area of technology, yet it can be easily handled as a separate unit in a transformer factory. Such unit will be equiped with special winding machines and impregnating equipment which, in turn, require specialized expertise and skills. The regional industry should wait until the growth of production output justifies setting up that unit. Once established, it should manufacture all the require condenser bushings.

It should be mentioned in this context that OLTC and condenser bushings are not fitted to distribution transformers. Instead, simple manual tap-changers and solid porcelain bushings are used.

2.6 Maturation period

The length of the maturation period is envisaged as follows:

Transformer category	Pre-production Phase	Production Phase	Maturation Period
Distribution (0.25-1.25 MVA)	3 years	5 years	8 years
Medium-power (6-40 MVA)	3 years	5 years	8 years
Large-power (75-200 MVA)	3 years	7 years	10 years

The length of the phases can only be approximated at this stage because it depends on the product mix and conditions (technological infrastructure, etc.) existing in the country hosting the factory. Those factors will be defined in the feasibility study.

The build-up of the factories is assumed to be as follows:

Distribution transformer factory	Pre-production year			Production year				
	1	2	3	4	5	6	7	8
Production output (percentage)				20	40	60	80	100
Production output (MVA)				1 200	2 400	3 600	4 800	6 000
Fixed investment[1/] (percentage)	20	40	40					
Cost of material (percentage)				20	40	60	80	100
Wages[2/] (percentage)				60	75	75	100	100

Medium power transformer factory	Pre-production year			Production year				
	1	2	3	4	5	6	7	8
Production output (percentage)				20	40	60	80	100
Production output (MVA)				1 200	2 400	3 600	4 800	6 000
Fixed investment (percentage)	20	40	40					
Cost of material (percentage)				20	40	60	80	100
Wages (percentage)				70	85	85	100	100

Large power transformer factory	Pre-production year			Production year						
	1	2	3	4	5	6	7	8	9	10
Production output (percentage)				1 500	3 000	4 500	6 000	7 500	9 000	10 000
Production output (MVA)				1 500	3 000	4 500	6 000	7 500	9 000	10 000
Fixed investment (percentage)	20	40	40							
Cost of material (percentage)				15	30	45	60	75	90	100
Wages (percentage)				70	70	90	90	100	100	100

1/ The build-up of personnel reflects the importance attached to the training function.

2/ To simplify computations, it is assumed that there is no overlapping between the two phases.

2.7 Development of the localization level

One objective of the regional industry will be to maximize the localization level in a manner compatible with the development of the local technological infrastructure (skills, supporting industries, etc.) without excessive investments that can make it uneconomical.

The major transformer components and the expected increase in those locally manufactured are given in table 2.1. The corresponding degree of localization, in value, is shown in figure 2.1, and indicates that 100 per cent localization could be achieved.

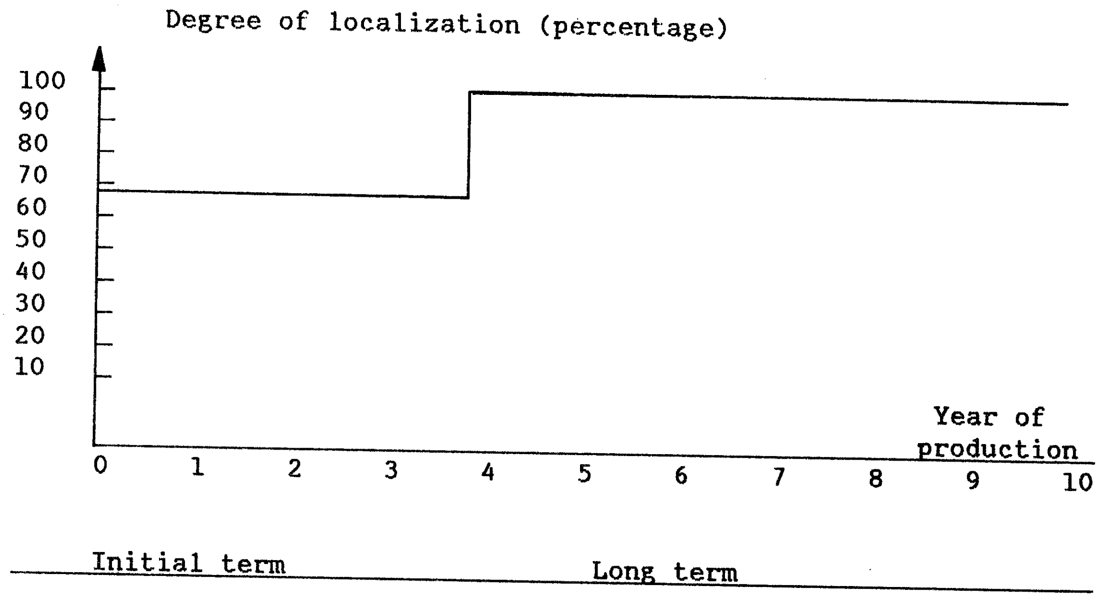
The procurement of components may be undertaken with the assistance of the collaborating manufacturer, in which case this should be stipulated in the contractual documents.

Table 2.1 Transformer components - locally manufactured and procured

	Initial term		Long term	
Components	Locally mfg.	Procured	Locally mfg.	Procured
Tank	x		x	
Cooler	x		x	
Core	x		x	
Winding assemblies		x	x	
Bushings	x		x	
Onload tap-changer	x		x	
Accessories	x		x	
Assembly	x		x	
Share	67%	33%	100%	

Source: Power equipment manufacture.

Figure 2.1 Development of the localization level for transformers



Source: Power equipment manufacture

2.8 Manufacturing linkages with other products

A transformer factory is specifically equipped for the manufacture of this kind of product. It is therefore not particularly suited for the manufacture of different products.

Products which use similar technology as power transformers include the following:

(a) Instrument transformers, known as current and potential transformers;

(b) Special transformers for furnaces, rectifiers and thyristor convertors, mining, and other industrial applications;

(c) Reactors.

Every power system requires instrument transformers for use in sub-stations, and the demand is large enough to justify an area in the medium-or large-power transformer factories to be set aside for this purpose. The demand for special transformers and reactors depends on the extent of the industrial activity in the region. Those products could be introduced gradually as demand picks up. While the manufacturing operations are somewhat similar, the design capability will have to be established at a specialist level for each type of product mentioned above.

CHAPTER 3*

ORGANIZATION OF THE FACTORY

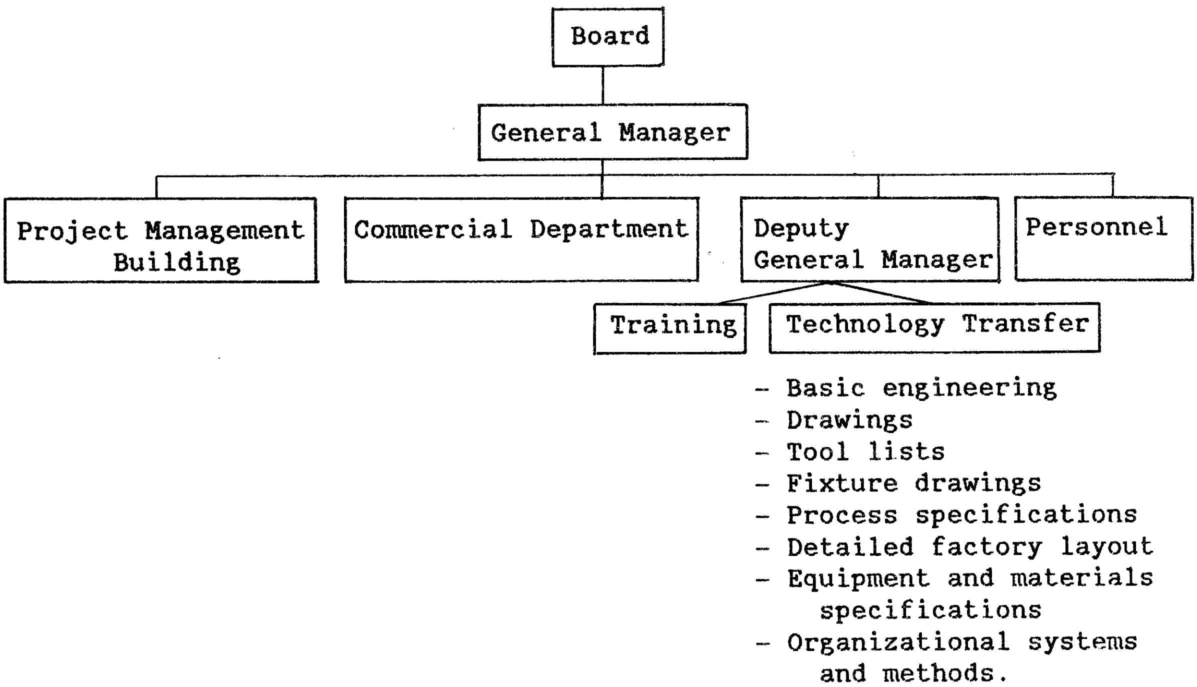
3.1 General

The organization of the factory during the pre-production (construction) phase and the production phase is described below:

3.2 Organization during the pre-production phase

Figure 3.1 illustrates the organization proposed for the construction of the factory buildings, procurement of production equipment and materials, securement of technical assistance from international manufacturers, recruitment of personnel, initiation of training programmes and all other preparatory activities.

Figure 3.1 Organization chart during the pre-production phase



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* This chapter is reproduced from volume II, part 2, and included here for the reader's convenience.

3.3 Organization during the production phase[1/]

As shown in figure 3.2, the factory will be organized into five divisions: Planning, Engineering, Production, Sales and Contracts, and Administration. The functions of each division are described in the following paragraphs.

(a) Planning division

This division is responsible for:

(i) Preparing flow charts and corresponding documents for equipping the various divisions with the essential systems and methods of organization:

- Order flow (ordering documents, parts lists, drawings, working documents, etc.);
- Control systems;
- Job descriptions, etc.;

(ii) Planning plant capacity and production controls;

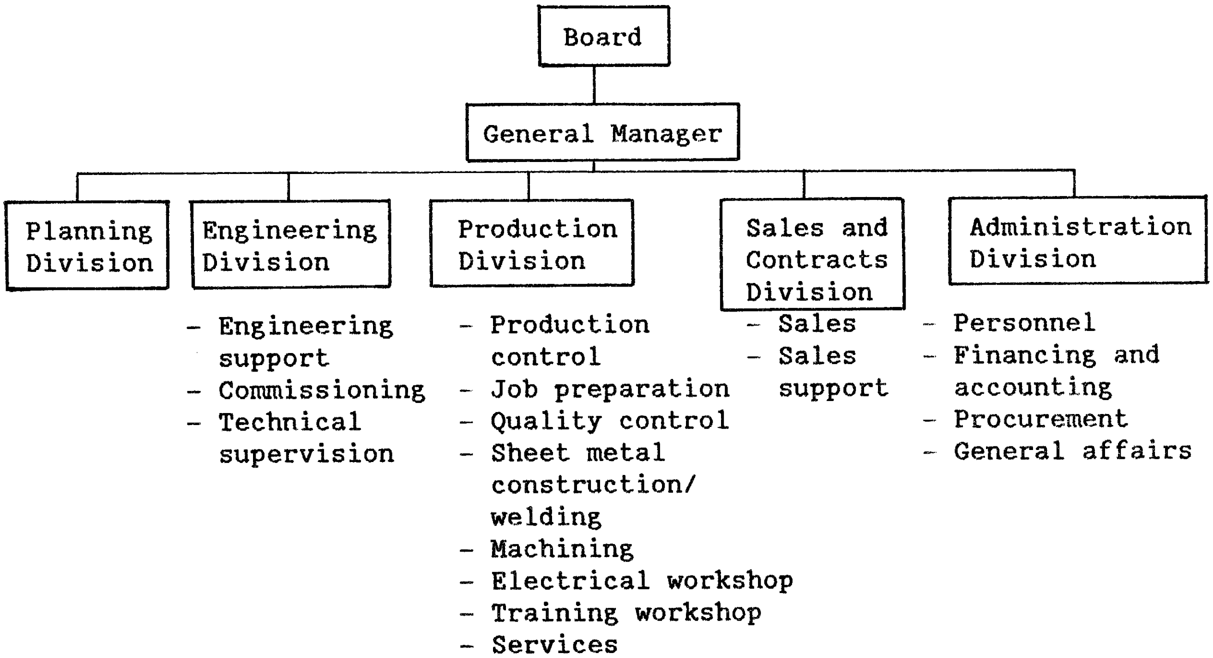
- Strategic planning;
- Budgeting;
- Production planning, etc.;

(iii) Information system:

- Reporting system;
- Organization of meetings, etc.

1/ Up to the end of the maturation period, an R & D function may be included in the engineering division. Thereafter, it may become a separate unit.

Figure 3.2 Organization chart during the production phase



(b) <u>Engineering division</u>

This division has five major functions:

(i) Engineering of products;
(ii) Adaptation to customer's demands;
(iii) Preparation of documents for the manufacture and development of products;
(iv) Supply of technical assistance to the buyers and users of the products;
(v) Testing of turbines and generators.

Since every order entails a high level of technical expertise and skills, it is necessary to establish tangible measures to ensure that the engineering operations attain the required high standards.

(c) <u>Production division</u>

This division is responsible for:

(i) Manufacturing the products within the specified time and cost, and according to the established quality standards;
(ii) Maximizing the work load and productivity of the factory;
(iii) Adequate training of personnel.

To manufacture highly sophisticated products such as power transformers, it is necessary to ensure that the workshop are efficiently organized, that the production control is adequate and that the work force is well trained and motivated.

Efficient organization requires a clear division of responsibilities for the production process among various sections. These responsibilities are designated according to the nature of the tasks to be performed, the relationships between the various tasks, and the optimum size of an organization unit.

Production scheduling and control must ensure punctual delivery, minimum process time, high workload, and consequently, low investment.

Adequate training emphasizes intensive training for foremen who will, in turn and supervise teams of workers. In addition to the OJT which the workers receive from their foremen, they must also be enrolled in a variety of training courses commensurate with the particular needs of their jobs. Because of its decisive impact on the outcome of the project, a separate section in the production division should be concerned exclusively with the training function.

In addition to the adequate training of workers, due attention should be paid to other ways of motivating the staff and achieving optimum production efficiency.

The following practices should be adopted:

(i) The workers should be kept well-informed about the factory, their workshops or offices and the production processes and should be encouraged to participate in solving problems that may arise;

(ii) Close co-operation between the maintenance group (included in the service section) and other production units should be established to carry out preventive maintenance to reduce expensive production interruptions and idle time of machines and equipment;

(iii) Drawings should be clear and operation plans easily understood; moreover, the required documents should always be available. Therefore, a well-organized documentation system should be established in the job-preparation section.

(d) Sales and Contracts division

This division is responsible for:

(i) Providing technical assistance and counselling to clients and potential customers;

(ii) Profitable "technical" selling within the regional market, and abroad later on;

(iii) Marketing;

(iv) Processing all paperwork relating to received orders.

For complex orders, senior salesmen should assume the responsibilities of project managers, supervise and manage the entire transaction.

The "Sales Support" section is responsible, among other things relating to sales, for maintaining documentation observing the potential market, and keeping close contacts with the Engineering and Production divisions. Salesmen for complex projects must be highly competent.

(e) Administrative division

This division is responsible for carrying out the services relating to:

(i) Personnel: recruitment, promotion, training, etc.;
(ii) Finance: accounting, cash-management, etc.;
(iii) Material: procurement, etc.

CHAPTER 4

MANUFACTURING REQUIREMENTS

4.1 General

Manufacturing requirements comprise:

(a) Land, buildings, roads, and utilities;
(b) Materials;
(c) Production and associated equipment;
(d) Personnel.

The values given below apply to full production output levels which are shown below:

Transformer category	Capacity range	Full production output
Distribution	0.25-1.25 MVA	6,000 MVA
Medium-power	6-40 MVA	6,000 MVA
Large-power	75-200 MVA	10,000 MVA

4.2 Land, buildings, roads, and utilities

(a) Land[1/]

	Area (m^2)
(i) Distribution transformers	90 000 m^2
(ii) Medium-power transformers	90 000 m^2
(iii) Large-power transformers	150 000 m^2

(b) Buildings

(i) Distribution transformers	
Manufacturing	15 000 m^2
Ancillary services	5 000 m^2
Total	20 000 m^2
(ii) Medium-power transformers	
Manufacturing	15 000 m^2
Ancillary services	5 000 m^2
Total	20 000 m^2

1/ Including reserve for possible expansions.

		Area (m2)
(ii)	Large-power transformers	
	Manufacturing	25 000 m^2
	Ancillary services	8 000 m^2
	Total	33 000 m^2

The manufacturing area consists of the following sections:

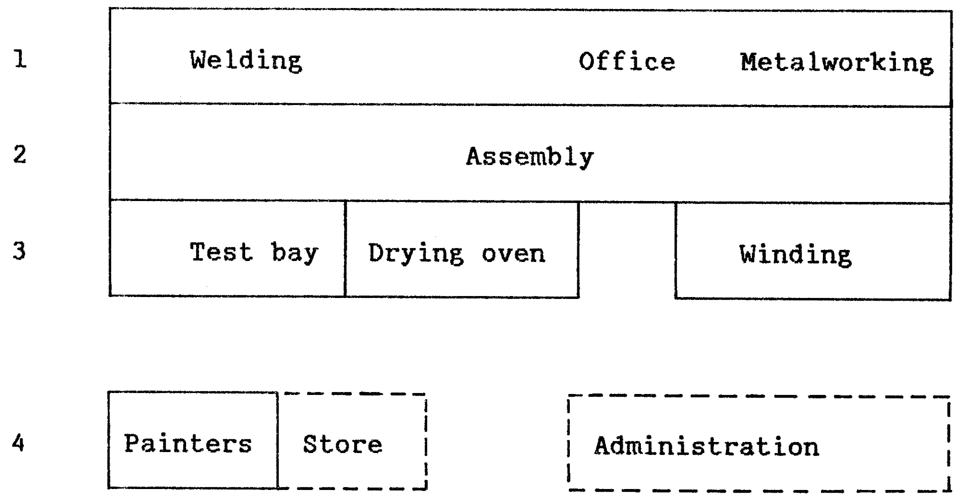
Function	Area (percentage)	Height of crane hook(m)	Maximum crane capacity (tons)
Welding, including painting shop	20	8	30
Metal working shop	7	8	20
Cores and bushings	20	8	20
Winding shops, including drying oven	15	8	10
Test bay	8	16	5
Assembly	30	16	200

The ancillary services include the following:

Energy supply
Fire-fighting system
Internal transport
Storage
Forwarding and crates
Administration
Training centre
Cafeteria
Maintenence and repair
Tool making

A layout plan for the transformer factories is illustrated in figure 4.1.

Figure 4.1 Layout plan for the transformer factory



Source: Power equipment manufacturer

(c) Roads

Approach roads or railway lines must be capable of carrying loads up to 200 tons.

(d) Utilities

	Transformer category		
	Distribution	Medium-power	Large-power
Electric power supply	3 MW	3 MW	5 MW
Annual electric power consumption	3 000 MWh	3 000 MWh	5 000 MWh
Annual fuel consumption	3 000 tons	3 000 tons	5 000 tons
Annual water consumption	150 000 m^3	150 000 m^3	250 000 m^3

4.3 Materials

The major materials required are:

Electrical steel sheets
Steel plates
Steel tubes
Copper strips
Rolled and drawn copper rods

Insulating materials
Non-magnetic materials
Oil
Laminated wood beams, slabs and rings

During the production phase, some components will be imported until local capabilities are established. This was illustrated in table 8.

4.4 Production and associated equipment

The following is a list of the main equipment required for the production of units up to 200 MVA. For smaller units, smaller sizes of the same machines and equipment will be needed; and the high-voltage laboratory can be dispensed with.

(a) Welding, including machining of tanks:
Sand-blasting equipment 5 x 5 x 10
Drilling machines
Milling machines
Centre lathes
Jig boring machines
Plate bending machine 4m wide
Welding equipment (argon and electrodes)
Press
Paint spraying booths

(b) Metalworking:
Roll shears
Plate cutting and trimming machines
Heat treatment plant
Measuring and inspection equipment

(c) Production of windings and insulation:
Small machines (cutting, grinding, shaping, glueing)
Winding stabilization oven
Impregnating plant
Miscellaneous tools, e.g. soldering etc.
Winding mandrels.

(d) Core steel processing:
Fork lift truck
Slitter
Shear
Digital scale
Spider frame and upender
Core band and miscellaneous tooling

(e) Bushing manufacture:
Core winder 1-3ft rod
Core winder 3-15ft rod
Overhead crane
Treat tank
Core storage tank
Bushing flush and fill tower
Electrical test
Dielectric
Impulse

(f) Assembly:
Tunnel furnace 10m long
Vertical furnace 10 x 5 x 5m (kerosene drying)
Oil storage tanks (200 tons) with anti-moisture precautions
Oil processing equipment (stationary and mobile)
Auxiliary facilities (platforms, mandrels, jacks)

(g) Test bay:
40 MVA source for 50/60 Hz (1 or 2 large generators or 1 small generator with capacitor bank)
Small generators for loss measurements (up to 2000 MVA)
Rectifiers and DC motors
Generator rated 3 MW, 200 Hz for induced voltage test
Measuring instruments, instrument transformers
H.V. test transformer 500 kV, 1 MVA
Surge generator for 2.4 MVA, 200 kV
Screened high-voltage laboratory (partial discharge and noise).

4.5 Personnel

Category	Number of personnel		
	Distribution transformers	Medium-power transformers	Large-power transformers
Division and department managers	12	12	12
Engineers	17	19	20
Draftsmen	10	13	15
Technicians	68	76	78
Foremen	38	44	63
Skilled workers	350	375	488
Unskilled workers	140	150	190
Clerical	113	138	161
Total a/	748	827	1 027

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a/ Almost 20 per cent higher than suggested by international manufacturer.

The distribution of personnel among the various divisions in the factory is approximately as follows:

	Number of personnel		
General Manager's Office	Distribution transformers	Medium-power transformers	Large-power transformers
General manager	1	1	1
Clerical	2	2	2
Total	3	3	3
Planning Division			
General manager	1	1	1
Clerical	2	2	2
Engineers	2	2	2
Total	5	5	5
Engineering Division			
Managers	2	2	2
Clerical	3	4	5
Engineers	5	7	8
Technicians	28	36	38
Draftsmen	10	13	15
Total	48	62	68
Production Division			
Managers	5	5	5
Clerical	61	73	73
Engineers	8	8	8
Technicians	30	30	30
Foremen	38	44	63
Skilled workers	350	375	488
Unskilled workers	140	150	190
Total	632	685	857

	Number of personnel		
	Distribution transformers	Medium-power transformers	Large-power transformers
Sales and contracts Division			
Managers	1	1	1
Clerical	3	3	6
Engineers	2	2	2
Technicians	10	10	10
Total	16	16	19
Administration Division			
Managers	2	2	2
Clerical	42	54	73
Total	44	56	75

CHAPTER 5

FINANCIAL ASPECTS

5.1 General

The financial analysis presented in this study is applicable to full production output level: 6000 MVA/year for distribution transformers or for medium-power transformers, and 10,000 MVA/year for large-power transformers. All values (costs, wages, prices, etc.) are given in 1979 constant prices, and must be regarded as approximate values.

The analysis is performed for two groups of countries categorized according to the average wage level and construction cost. Group I includes the oil exporting countries, whereas Group II consists of the non-oil exporting countries.

5.2 Factors of cost

(a) The cost of land and construction as well as wages are estimated (in US$) as shown below:

	Group I	Group II
Land	$20/m^2$	$20/m^2$
Buildings		
(i) Distribution transformers		
Manufacturing	$360/m^2$	$270/m^2$
Ancillary services	$520/m^2$	$390/m^2$
(ii) Medium-power transformers		
Manufacturing	$433/m^2$	$325/m^2$
Ancillary services	$700/m^2$	$525/m^2$
(iii) Large-power transformers		
Manufacturing	$396/m^2$	$297/m^2$
Ancillary services	$600/m^2$	$450/m^2$

	Group I	Group II
Roads[1/]	50/m^2	50/m^2
Monthly wages[2/]		
Division and department manager	5 000	3 000
Engineer	4 000	2 500
Draftsman	1 800	1 250
Technician	1 800	1 250
Foreman	1 800	1 250
Skilled workers	1 200	850
Unskilled workers	600	425
Clerical	1 000	1 000

(b) The ex-factory 1979 prices of production equipment and materials are given below:

Production equipment	Cost in million US $
(i) Distribution transformers	
Metal working	1.1
Winding	1.1
Welding and machining	1.6
Assembly	1.7
Testing	1.2
Auxiliaries	3.0
Total	9.7
(ii) Medium-power transformers	
Metal working	1.3
Winding	1.3
Welding and machining	2.1
Assembly	2.2
Testing	3.0
Auxiliaries	4.2
Total	14.1

1/ Within the site only.
2/ Wages include salaries and all fringe benefits.

(iii) Large-power transformers	
Metal working	1.6
Winding	1.6
Welding and machining	2.8
Core steel processing	1.0
Bushing manufacture	1.5
Assembly	3.0
Testing	4.0
Auxiliaries	5.0
Total	20.5

Materials and semi-finished parts	Cost in million US $
(i) Distribution transformers	
Materials	21.6
Semi-finished parts	5.4
Total	27.0
(ii) Medium-power transformers	
Materials	13.7
Semi-finished parts	5.5
Total	19.2
(iii) Large-power transformers	
Materials	13.7
Semi-finished parts	6.8
Total	20.5

(c) Royalty fees: 7.5 per cent[1/] of sales

(d) Selling price (US$)

(i) Distribution transformers	11.3/kVA
(ii) Medium-power transformers	9.6/kVA
(iii) Large-power transformers	7.0/kVA

(e) Maturation period

(i) Distribution transformers	8 years
(ii) Medium-power transformers	8 years
(iii) Large-power transformers	10 years

1/ Consisting of 4 per cent pure royalty and 3.5 per cent for technical assistance.

The build-up of production output and the distribution of the major costs during the maturation period are assumed as follows:

(i) Distribution transformers

	Pre-production year			Production year				
	1	2	3	4	5	6	7	8
Production output (percentage)				20	40	60	80	100
Fixed investment (percentage)	20	40	40					

	Pre-production year			Production year				
	1	2	3	4	5	6	7	8
Cost of material (percentage)				20	40	60	80	100
Wages (percentage)				60	75	75	100	100

(ii) Medium-power transformers

Production output (percentage)				20	40	60	80	100
Fixed investment (percentage)	20	40	40					
Cost of material (percentage)				20	40	60	80	100
Wages (percetage)				70	85	85	100	100

(iii) Large-power transformers

	Pre-production year			Production year						
	1	2	3	4	5	6	7	8	9	10
Production output (percentage)				15	30	45	60	75	90	100
Fixed investment (percentage)	20	40	40							
Cost of material (percentage)				15	30	45	60	75	90	100
Wages (percentage)				70	70	90	90	100	100	100

5.3 Analysis and Results

Financial analyses are carried out in annexes I, II and III for the three transformer categories. The results are presented in tables 5.1, 5.2 and 5.3 respectively and indicated that:

(a) The manufacture of transformers is economically viable. The rate of return is higher than that of turbines and generators, and is inversely proportionate to transformer size.

(b) The rate of return and payback period are influenced by plant location (Group I vs. Group II). The impact of the location factor is proportionate to transformer size. Thus it would be more profitable to locate all factories in Group II countries. However, the distribution transformer factory could be located in Group I countries with relatively less negative impact compared to the other transformer factories.

(c) Since the regional market, towards the end of the 1990s will be able to absorb 50 per cent more capacity than the above factories can provide, additional factories may be established in different locations.

(d) The results obtained here are preliminary and should be substantiated in a detailed feasibility study.

Table 5.1 Decision matrix for distribution (0.25-1.25 MVA) transformers with an annual output of 6,000 MVA

No.	Item descripton	Group I	Group II
1.	Total fixed capital, all equity basis (million US$)	44	40
2.	Total fixed capital, with long term loans (million US$)	47	43
	- equity	24	22
	- loan	23	21
3.	Working capital, assumed as short borrowing (million US$)	14.1	13.5
4.	Number of persons employed	748	748
5.	Payback period (years)	4.8	4.1
6.	Return on equity in 6th year of operation (%)	74.6	96.6
7.	Average undiscounted rate of return over 10 year-period on total cash (% per annum)	26.9	39.1
8.	Internal rate of return (% per annum)	14.8	18.6
9.	Fixed capital per person employed (in thousand US$)	58.8	53.5
10.	Unit cost of production (US$/kVA)	8.3	7.8

<u>Source</u>: Joint ECWA/UNIDO Industry Division.

Table 5.2. Decision matrix for medium-power (6-40 MVA) transformers with an annual output of 6,000 MVA

No. Item description	Group I	Group II
1. Total fixed capital, all equity basis (million US$)	51	46
2. Total fixed capital, with long term loans(million US$)	55	50
- equity	28	25
- loan	27	25
3. Working capital, assumed as short borrowing(million US$)	11.3	10.6
4. Number of persons employed	827	827
5. Payback period (years)	6	5.2
6. Return on equity in 6th year of operation (%)	51	72
7. Average undiscounted rate of return over 10 year-period on total cash (% per annum)	16.6	27.5
8. Internal rate of return (% per annum)	10.3	15
9. Fixed capital per person employed (thousand US$)	61.7	55.6
10. Unit cost of production (US$/kVA)	7.3	6.7

Source: Joint ECWA/UNIDO Industry Division.

Table 5.3. Decision matrix for large-power (75-200 MVA) transformers, with an annual output of 10,000 MVA

No. Item description	Group I	Group II
1. Total fixed capital, all equity basis (million US$)	69	61
2. Total fixed capital, with long-term loans(million US$)	75	66
- equity	38	33
- loan	37	33
3. Working capital, assumed as short borrowing(million US$)	13	12
4. Number of persons employed	1 027	1 027
5. Payback period (years)	7.4	6
6. Return on equity in 6th year of operation (%)	44.7	64.1
7. Average undiscounted rate of return over 10 year-period on total cash (% per annum)	11.5	21.6
8. Internal rate of return (% per annum)	7.6	12.4
9. Fixed capital per person employed (thousand US$)	67.2	59.4
10. Unit cost of production (US$/kVA)	5.1	4.6

Source: Joint ECWA/UNIDO Industry Division.

ANNEX I

FINANCIAL ANALYSIS FOR DISTRIBUTION TRANSFORMERS

Table I.1. Fixed capital cost for distribution (0.25-1.25MVA) transformers with an annual output of 6,000 MVA
(In thousand US dollars)

	Element of cost	Group I	Group II
A.	Land and site development		
A1	Land	1 800	1 800
A2	Grading (2 US$/m^2 for an estimated area of 90 000m^2)	180	180
A3	Fencing	30	30
A4	Roads	200	200
A5	Drainage, sewage, street lighting	250	250
A6	Temporary structure to supervise construction	600	360
A7	Contingencies (10 % of items A2 to A6)	126	102
	Total A	3 186	2 922
B.	Buildings and civil works		
B1	Buildings	8 000	6 000
B2	Contingencies (10 % of B1)	800	600
	Total B	8 800	6 600
C.	Plant and equipment		
C1	Production equipment	9 700	9 700
C2	Freight, insurance, transport (7 % of C1)	679	679
C3	Erection and commissioning (10 % of C1)	970	970
C4	Utilities and service equipment	2 000	1 500
C5	Contingencies (10 % of items C1 to C4)	1 335	1 285
	Total C	14 684	14 134
D.	Project engineering and pre-operation costs		
D1	Project engineering (3 % of items A2 to C5)	746	656
D2	Project establishment	4 000	3 000
D3	Royalties (7.5 % of annual sales discounted at 9 % for the first 5 years of production)	10 900	10 900
D4	Interest during construction period (on 23,000/21,000 US $ at 9 %)	3 105	2 835
D5	Contingencies (10 % of items D1 to D4)	1 875	1 739
	Total D	20 626	19 130
	Grand Total A to D	47 296	42 786
E.	Financing		
E1	Equity	24 000	22 000
E2	Loan	23 000	21 000

Source: Joint ECWA/UNIDO Industry Division.

Table I.2. Annual cost of production for distribution (0.25-1.25MVA) transformers with an annual output of 6,000 MVA
(In thousand US dollars)

	Element of cost	Group I	Group II
1.	Input material		
	(a) Ex-factory	27 000	27 000
	(b) Freight, insurance, transport (7% of 1a)	1 890	1 890
2.	Wages	11 446	8 322
3.	Electricity (5 cents/kWh)	150	150
4.	Water (30 cents/m^3)	45	45
5.	Fuel	300	600
6.	Maintenance supplies for plant and equipment (5% of item C, table I.1)	734	707
7.	Maintenance supplies for civil works (3% of items A2 to A5 plus B, table I.1)	284	218
8.	Establishment cost (2.5% of value of sales)	1 700	1 700
9.	Depreciation and amortization		
	(a) Plant and equipment (10% of item C, table I.1)	1 468	1 413
	(b) Civil works (3% of items A2 to A5 plus B, table I.1)	284	218
	(c) Amortization of projecting costs (over 10 years)	2 063	1 913
10.	Interest on long-term loan (9% on half the loan)	1 035	945
11.	Interest on working capital (10%)	1 410	1 348
12.	Contingencies (5% of items 3 to 8 plus 10 and 11)	283	286
	Total cost of production	50 092	46 755
13.	Unit cost of production (US $/kVA)	8.3	7.8

Source: Joint ECWA/UNIDO Industry Division.

Table I.3. Estimated working capital for distribution (0.25-1.25MVA) transformers with an annual output of 6,000 MVA.
(In thousand US dollars)

	Element of cost	Basis of provision	Group I	Group II
1.	Wages[a/]	1 month	954	694
2.	Materials[b/]	4 months	9 630	9 630
3.	Establishment cost[c/]	1 month	354	364
4.	Finished inventory[d/]	1/2 month	1 858	1 732
5.	Bills receivable[e/]	1 month	3 715	3 465
	Total		16 511	15 885
6.	Less bills payable[f/]	1 month	2 408	2 408
	Average working capital		14 103	13 477

Source: Joint ECWA/UNIDO Industry Division.

a/ Item 2, table I.2

b/ Item 1, table I.2

c/ Items 3 to 8 plus 10, table I.2

d/ Items 1 to 8 plus 10, table I.2

e/ Items 1 to 8 plus 10, table I.2

f/ Item 1, table I.2

Table I.4. Cash flow statement for distribution (0.25-1.25 MVA) transformers with an annual output of 6,000 MVA in group I
(In thousand US dollars)

Year from start of operation	(3)	(2)	(1)	1	2	3	4	5	6	7	8	9	10
A. Fixed investment	(8 776)	(17 552)	(17 552)										
		(43 880)											
B. Cash outflow on:													
1. Materials				5 778	11 556	17 334	23 112	28 890	28 890	28 890	28 890	28 890	28 890
2. Wages and salaries				6 868	8 585	8 585	11 446	11 446	11 446	11 446	11 446	11 446	11 446
3. Utilities				800	1 200	1 600	2 000	2 000	2 000	2 000	2 000	2 000	2 000
4. Maintenance supplies for plant and equipment				734	734	734	734	734	734	734	734	734	734
5. Maintenance supplies for civil works				284	284	284	284	284	284	284	284	284	284
6. Running cost				340	680	1 020	1 360	1 700	1 700	1 700	1 700	1 700	1 700
7. Interest on working capital				282	564	846	1 128	1 410	1 410	1 410	1 410	1 410	1 410
8. Contingencies (5% of items 3 to 7)				122	173	224	275	306	306	306	306	306	306
Total B				15 208	23 776	30 627	40 339	46 770	46 770	46 770	46 770	46 770	46 770
C. Inflow through sales				13 600	27 200	40 800	54 400	68 000	68 000	68 000	68 000	68 000	68 000
D. Salvage value				-	-	-	-	-	-	-	-	-	8 486
E. (Outflow)/Inflow	(8 776)	(17 552)	(17 552)	(1 608)	3 424	10 173	14 061	21 230	21 230	21 230	21 230	21 230	29 716
		(43 880)											

Source: Joint ECWA/UNIDO Industry Division.

Table I.5. Cash flow statement for distribution (0.25-1.25 MVA) transformers with an annual output of 6,000 MVA in group II
(In thousand US dollars)

Year from start of operation	(3)	(2)	(1)	1	2	3	4	5	6	7	8	9	10
A. Fixed investment	(7 934)	(15 867)	(15 867)										
		(39 668)											
B. Cash outflow on:													
1. Materials				5 778	11 556	17 334	23 112	28 890	28 890	28 890	28 890	28 890	28 890
2. Wages and salaries				4 993	6 242	6 242	8 322	8 332	8 322	8 322	8 322	8 322	8 332
3. Utilities				600	900	1 200	1 500	1 500	1 500	1 500	1 500	1 500	1 500
4. Maintenance supplies for plant and equipment				707	707	707	707	707	707	707	707	707	707
5. Maintenance supplies for civil works				218	218	218	218	218	218	218	218	218	218
6. Running cost				340	680	1 020	1 360	1 700	1 700	1 700	1 700	1 700	1 700
7. Interest on working capital				269	539	809	1 078	1 348	1 348	1 348	1 348	1 348	1 348
8. Contingencies (5% of items 3 to 7)				107	152	198	243	274	274	274	274	274	274
Total B				13 012	21 048	27 728	36 540	42 959	42 959	42 959	42 959	42 959	42 959
C. Inflow through sales				13 600	27 200	40 800	54 400	68 000	68 000	68 000	68 000	68 000	68 000
D. Salvage value				-	-	-	-	-	-	-	-	-	6 940
E. (Outflow)/Inflow	(7 934)	(15 867)	(15 867)	588	6 152	13 072	17 860	25 041	25 041	25 041	25 041	25 041	31 981
		(39 668)											

Source: Joint ECWA/UNIDO Industry Division.

Table I.6: Discounted cash flow and rate of return for distribution (0.25-1.25 MVA) transformers with an annual output of 6,000 MVA in group I (in thousand US dollars and per cent)

	Year from start of operation	Undiscounted amount	Compounded/Discounted at 14 per cent Factor	Compounded/Discounted at 14 per cent Value	Compounded/Discounted at 15 per cent Factor	Compounded/Discounted at 15 per cent Value
A. Outflows	(3)	(8 777)	1.4815	(13 002)	1.5209	(13 347)
	(2)	(17 552)	1.2996	(22 810)	1.3225	(23 213)
	(1)	(17 552)	1.1400	(20 009)	1.1500	(20 185)
Total A	0	(43 880)		(55 821)		(56 745)
B. Net inflows	1	(1 608)	0.86000	(1 383)	0.85000	(1 367)
	2	3 424	0.73960	2 532	0.72250	2 474
	3	10 173	0.63606	6 471	0.61413	6 248
	4	14 061	0.54701	7 691	0.52201	7 340
	5	21 230	0.47043		0.44371	
	6	21 230	0.40457	1.77948	0.37715	1.64554
	7	21 230	0.34793	x 21 230	0.32058	x 21 230
	8	21 230	0.29922	= 37 778	0.27249	= 34 934
	9	21 230	0.25733		0.23162	
	10	29 716	0.22130	6 576	0.19687	5 850
Total B		161 916		59 665		55478

Average undiscounted rate of return (per cent) $= \frac{161\ 916 - 43\ 880}{43\ 880 \times 10} \times 100 = 26.9$

Internal rate of return (per cent) $= 14 + \frac{(59\ 665 - 55\ 821) \times (15-14)}{(59\ 665-55\ 821) + (56\ 145-55\ 478)} \times 100$

$= 14.8$

Payback period = 4.8 years

Source: Joint ECWA/UNIDO Industry Division.

Table I.7. Discounted cash flow and rate of return for distribution (0.25-1.25 MVA) transformers with an annual output of 6,000 MVA in group II (in thousand US dollars and per cent)

	Year from start of operation	Undiscounted amount	Compounded/Discounted at 18 per cent Factor	Compounded/Discounted at 18 per cent Value	Compounded/Discounted at 19 per cent Factor	Compounded/Discounted at 19 per cent Value
A. Outflows	(3)	(7 934)	1.6430	(13 036)	1.6852	(13 370)
	(2)	(15 867)	1.3924	(22 093)	1.4161	(22 469)
	(1)	(15 867)	1.1800	(18 723)	1.1900	(18 882)
Total A	0	(39 668)		(53 852)		(54 721)
B. Net inflows	1	588	0.82000	482	0.81000	476
	2	6 152	0.67240	4 137	0.65610	4 036
	3	13 072	0.55137	7 207	0.53144	6 947
	4	17 860	0.45212	8 075	0.43047	7 688
	5	25 041	0.37074		0.34868	
	6	25 041	0.30401	1.2961	0.28243	1.19527
	7	25 041	0.24929	x 25 041	0.22877	x 25 041
	8	25 041	0.20441	= 32 454	0.18530	= 29 930
	9	25 041	0.16762		0.15009	
	10	31 981	0.13745	4 396	0.12158	3 888
Total B		194 858		56 751		52 965

Average undiscounted rate of return (per cent) $= \frac{194\ 858 - 39\ 668}{39\ 668 \times 10} \times 100 = 39.1$

Internal rate of return (per cent) $= 18 + \frac{(56\ 751 - 53\ 852) \times (19 - 18)}{(56\ 751 - 53\ 852) + (54\ 721 - 52\ 965)} \times 100$

$= 18.6$

Payback period = 4.1 years

Source: Joint ECWA/UNIDO Industry Division.

ANNEX II

FINANCIAL ANALYSIS FOR MEDIUM-POWER TRANSFORMERS

Table II.1. Fixed capital cost for medium-power (6-40 MVA) transformers with an annual output of 6,000 MVA
(In thousand US dollars)

Element of cost		Group I	Group II
A.	Land and site development		
A1	Land	1 800	1 800
A2	Grading (2 US$/m² for an estimated area of 90 000 m²)	180	180
A3	Fencing	30	30
A4	Roads	200	200
A5	Drainage, sewage, street lighting	250	250
A6	Temporary structure to supervise construction	600	360
A7	Contingencies (10% of items A2 to A6)	126	102
	Total A	3 186	2 922
B.	Buildings and civil works		
B1	Buildings	10 000	7 500
B2	Contingencies (10 % of B1)	1 000	750
	Total B	11 000	8 250
C.	Plant and equipment		
C1	Production equipment	14 100	14 100
C2	Freight, insurance, transport (7 % of C1)	987	987
C3	Erection and commissioning (10 % of C1)	1 410	1 410
C4	Utilities and service equipment	2 000	1 500
C5	Contingencies (10 % of items C1 to C4)	1 850	1 800
	Total C	20 347	19 797
D.	Project engineering and pre-operation costs		
D1	Project engineering (3 % of items A2 to C5)	982	875
D2	Project establishment	5 000	3 500
D3	Royalties (7.5 % of annual sales discounted at 9 % for the first 5 years of production)	9 300	9 300
D4	Interest during construction period (on 27,000/25,000 US $ at 9 %)	3 645	3 375
D5	Contingencies (10 % of items D1 to D4)	1 893	1 705
	Total D	20 820	18 755
	Grand Total A to D	55 353	49 724
E.	Financing		
E1	Equity	28 000	25 000
E2	Loan	27 000	25 000

Source: Joint ECWA/UNIDO Industry Division.

Table II.2. Annual cost of production for medium-power (6-40 MVA) transformers with an annual output of 6,000 MVA
(In thousand US dollars)

	Element of cost	Group I	Group II
1.	Input material		
	(a) Ex-factory	19 200	19 200
	(b) Freight, insurance, transport (7 % of 1a)	1 344	1 344
2.	Wages	12 641	9 245
3.	Electricity (5 cents/kWh)	150	150
4.	Water (30 cents/m^3)	45	45
5.	Fuel	300	600
6.	Maintenance supplies for plant and equipment (5 % of item C, table II.1)	1 017	990
7.	Maintenance supplies for civil works (3 % of items A2 to A5 plus B table II.1)	350	267
8.	Establishment cost (2.5 % of value of sales)	1 450	1 450
9.	Depreciation and amortization		
	(a) Plant and equipment (10 % of item C1 table II.1)	2 035	1 980
	(b) Civil works (3 % of items A2 to A5 plus B, table II.1)	350	267
	(c) Amortization of projecting costs (over 10 years)	2 082	1 876
10.	Interest on long term loan (9 % on half the loan)	1 215	1 125
11.	Interest on working capital (10 %)	1 128	1 059
12.	Contingencies (5 % of items 3 to 8 plus 10 and 11)	283	284
	Total cost of production	43 590	39 882
13.	Unit cost of production (US$ per kVA)	7.3	6. 65

Source: Joint ECWA/UNIDO Industry Division.

Table II.3. Estimated working capital for medium-power (6-40 MVA) transformers with an annual output of 6,000 MVA (In thousand US dollars)

Element of cost	Basis of provision	Group I	Group II
1. Wages[a]	1 month	1 053	770
2. Materials[b]	4 months	6 848	6 848
3. Establishment cost[c]	1 month	377	386
4. Finished inventory[d]	1/2 month	1 571	1 434
5. Bills receivable[e]	1 month	3 142	2 868
Total		12 991	12 306
6. Less bills payable[f]	1 month	1 712	1 712
Average working capital		11 279	10 594

Source: Joint ECWA/UNIDO Industry Division.

a/ Item 2, table II.2

b/ Item 1, table II.2

c/ Items 3 to 8 plus 10, table II.2

d/ Items 1 to 8 plus 10, table II.2

e/ Items 1 to 8 plus 10, table II.2

f/ Item 1, table II.2

Table II.4. Cash flow statement for medium power (6-40 MVA) transformers with an annual output of 6,000 MVA in group I
(In thousand US dollars)

Year from start of operation	(3)	(2)	(1)	1	2	3	4	5	6	7	8	9	10
A. Fixed investment	(10 269)	(20 538)	(20 538)										
		(51 345)											
B. Cash outflow on:													
1. Materials				4 109	8 218	12 326	16 435	20 544	20 544	20 544	20 544	20 544	20 544
2. Wages and salaries				8 848	10 744	10 744	12 641	12 641	12 641	12 641	12 641	12 641	12 641
3. Utilities				800	1 200	1 600	2 000	2 000	2 000	2 000	2 000	2 000	2 000
4. Maintenance supplies for plant and equipment				1 017	1 017	1 017	1 017	1 017	1 017	1 017	1 017	1 017	1 017
5. Maintenance supplies for civil works				350	350	350	350	350	350	350	350	350	350
6. Running cost				290	580	870	1 160	1 450	1 450	1 450	1 450	1 450	1 450
7. Interest on working capital				226	452	677	902	1 128	1 128	1 128	1 128	1 128	1 128
8. Contingencies (5% of items 3 to 7)				134	180	226	271	297	297	297	297	297	297
Total B				15 774	22 741	27 810	34 776	39 427	39 427	39 427	39 427	39 427	39 427
C. Inflow through sales				11 600	23 200	34 800	46 400	58 000	58 000	58 000	58 000	58 000	58 000
D. Salvage value				-	-	-	-	-	-	-	-	-	10 026
E. (Outflow)/Inflow	(10 269)	(20 538)	(20 538)	(4 174)	459	6 990	11 624	18 573	18 573	18 573	18 573	18 573	28 599
		(51 345)											

Source: Joint ECWA/UNIDO Industry Division.

Table II.5. Cash flow statement for medium-power (6-40 MVA) transformers with an annual output of 6,000 MVA in group II
(In thousand US dollars)

Year from start of operation	(3)	(2)	(1)	1	2	3	4	5	6	7	8	9	10
A. Fixed investment	(9 202)	(18 405)	(18 405)										
		(46 012)											
B. Cash outflow on:													
1. Materials				4 109	8 218	12 326	16 435	20 544	20 544	20 544	20 544	20 544	20 544
2. Wages and salaries				6 470	7 857	7 857	9 243	9 243	9 243	9 243	9 243	9 243	9 243
3. Utilities				600	900	1 200	1 500	1 500	1 500	1 500	1 500	1 500	1 500
4. Maintenance supplies for plant and equipment				990	990	990	990	990	990	990	990	990	990
5. Maintenance supplies for civil works				267	267	267	267	267	267	267	267	267	267
6. Running cost				290	580	870	1 160	1 450	1 450	1 450	1 450	1 450	1 450
7. Interest on working capital				212	424	636	847	1 059	1 059	1 059	1 059	1 059	1 059
8. Contingencies (5% of items 3 to 7)				118	158	198	238	263	263	263	263	263	263
Total B				13 056	19 394	24 344	30 680	35 316	35 316	35 316	35 316	35 316	35 316
C. Inflow through sales				11 600	23 200	34 800	46 400	58 000	58 000	58 000	58 000	58 000	58 000
D. Salvage value				-	-	-	-	-	-	-	-	-	8 106
E. (Outflow)/Inflow	(9 202)	(18 405)	(18 405)	(1 456)	3 806	10 456	15 720	22 684	22 684	22 684	22 684	22 684	30 790
		(46 012)											

Source: Joint ECWA/UNIDO Industry Division.

Table II.6. Discounted cash flow and rate of return for medium-power (6-40 MVA) transformers with an annual output of 6,000 MVA in group I
(in thousand US dollars and per cent)

	Year from start of operation	Undiscounted amount	Compounded/discounted at 10 per cent Factor	Compounded/discounted at 10 per cent Value	Compounded/discounted at 11 per cent Factor	Compounded/discounted at 11 per cent Value
A. Outflows	(3)	(10 269)	1.331	(13 668)	1.3676	(14 044)
	(2)	(20 538)	1.210	(24 851)	1.2321	(25 305)
	(1)	(20 538)	1.100	(22 592)	1.1100	(22 797)
Total A	0	(51 345)		(61 111)		(62 146)
B. Net inflows	1	(4 174)	0.90000	(3 344)	0.89000	(3 715)
	2	459	0.81000	295	0.79210	364
	3	6 990	0.72900	3 593	0.70497	4 928
	4	11 624	0.65610	4 785	0.62742	7 293
	5	18 573	0.59049		0.55841	
	6	18 573	0.53144	2.4181	0.49698	2.4887
	7	18 573	0.47830	x 18 573	0.44231	x 18 573
	8	18 573	0.43047	=	0.39366	=
	9	18 573	0.38742	44 911	0.35036	46 223
	10	28 599	0.34868	9 972	0.31182	8 918
Total B		136 363		60 212		64 011

Average undiscounted rate of return (per cent) $= \frac{(136\ 363 - 51\ 345)}{51\ 345 \times 10} \times 100 = 16.6$

Internal rate of return (per cent) $= 10 + \frac{(60\ 212 - 61\ 111) \times (11 - 10)}{(60\ 212 - 61\ 111) + (62\ 146 - 64\ 011)} \times 100 = 10.3$

Payback period = 6 years

Source: Joint ECWA/UNIDO Industry Division.

Table II.7 Discounted cash flow and rate of return for medium-power (6-40 MVA) transformers with an annual output of 6,000 MVA in group II (in thousand US dollars and per cent)

	Year from start of operation	Undiscounted amount	Compounded/Discounted at 15 %	
			Factor	Value
A. Outflows	(3)	(9 202)	1.5209	(13 995)
	(2)	(18 405)	1.3225	(24 341)
	(1)	(18 405)	1.15	(21 166)
Total A	0	(46 012)		(59 502)
B. Net inflows	1	(1 456)	0.85	(1 238)
	2	3 806	0.7225	2 750
	3	10 456	0.61413	6 421
	4	15 720	0.52201	8 206
	5	22 684	0.44371	
	6	22 684	0.37715	1.64554 x
	7	22 684	0.32058	
	8	22 684	0.27249	22 684 =
	9	22 684	0.23162	37 327
	10	30 790	0.19687	6 062
Total B		172 736		59 528

Average undiscounted rate of return (per cent) $= \frac{172\ 736 - 46\ 012}{46\ 012 \times 10} \times 100 = 27.5$

Internal rate of return (per cent) = 15

Payback period = 5.2 years

Source: Joint ECWA/UNIDO Industry Division.

ANNEX III

FINANCIAL ANALYSIS FOR LARGE-POWER TRANSFORMERS

Table III.1. Fixed capital cost for large-power (75-200 MVA) transformers with an annual output of 10,000 MVA
(In thousand US dollars)

	Element of cost	Group I	Group II
A.	Land and site development		
A1	Land	3 000	3 000
A2	Grading (2 $/m^2 for an estimated area of 150 000 m^2)	300	300
A3	Fencing	45	45
A4	Roads	300	300
A5	Drainage, sewage, street lighting	350	350
A6	Temporary structure to supervise construction	600	360
A7	Contingencies (10 % of items A2 to A6)	160	136
	Total A	4 755	4 491
B.	Buildings and civil works		
B1	Buildings	14 700	11 000
B2	Contingencies (10 % of B1)	1 470	1 100
	Total BC	16 170	12 100
C.	Plant and equipment		
C1	Production equipment	20 500	20 500
C2	Freight, insurance, transport (7 % of C1)	1 435	1 435
C3	Erection and commissioning (10 % of C1)	2 050	2 050
C4	Utilities and service equipment	3 000	2 000
C5	Contingencies (10 % of items C1 to C4)	2 699	2 599
	Total B	29 684	28 584
D.	Project engineering and pre-operation costs		
D1	Project engineering (3 % of items A2 to C5)	1 428	1 265
D2	Project establishment	7 000	5 000
D3	Royalties (7.5 % of annual sales discounted at 9 % for the first 5 years of production)	8 418	8 418
D4	Interest during construction period (on 37,000/33,000 US $ at 9 %)	4 995	4 455
D5	Contingencies (10 % of items D1 to D4)	2 184	1 914
	Total D	24 025	21 052
	Grand Total A to D	74 634	66 227
E.	Financing		
E1	Equity	38 000	33 000
E2	Loan	37 000	33 000

Source: Joint ECWA/UNIDO Industry Division.

Table III.2. Annual cost of production for large-power (75-200 MVA) transformers with an annual output of 10,000 MVA
(In thousand US dollars)

Element of cost	Group I	Group II
1. Input material		
(a) Ex-factory	20 500	20 500
(b) Freight, insurance, transport (7 % of 1a)	1 435	1 435
2. Wages	15 377	11 252
3. Electricity (5 cents/kWh)	250	250
4. Water (30 cents/m^3)	75	75
5. Fuel	500	1 000
6. Maintenance supplies for plant and equipment (5 % of item C, table III.1)	1 484	1 429
7. Maintenance supplies for civil works (3 % of items A2 to A5 plus B, table III.1)	515	393
8. Establishment cost (2.5 % of value of sales)	1 750	1 750
9. Depreciation and amortization		
(a) Plant and equipment (10 % of item C, table III.1)	2 968	2 858
(b) Civil works (3 % of items A2 to A5 plus B, table III.1)	515	393
(c) Amortization of projecting costs (over 10 years)	2 403	2 105
10. Interest on long-term loan (9 % on half the loan)	1 665	1 485
11. Interest on working capital (10%)	1 273	1 190
12. Contingencies (5 % of items 3 to 8 plus 10 and 11)	376	379
Total cost of production	51 086	46 494
13. Unit cost of production (US$ per kVA)	5.1	4.65

Source: Joint ECWA/UNIDO Industry Division.

Table III.3. Estimated working capital for large-power (75-200 MVA) transformers with an annual output of 10,000 MVA (In thousand US dollars)

Element of cost	Basis of provision	Group I	Group II
1. Wages[a/]	1 month	1 281	938
2. Materials[b/]	4 months	7 312	7 312
3. Establishment cost[c/]	1 month	520	532
4. Finished inventory[d/]	1/2 month	1 815	1 649
5. Bills receivable[e/]	1 month	3 630	3 298
Total		14 558	13 729
6. Less bills payable[f/]	1 month	1 828	1 828
Average working capital		12 730	11 901

Source: Joint ECWA/UNIDO Industry Division.

a/ Item 2, table III.2

b/ Item 1, table III.2

c/ Items 3 to 8 plus 10, table III.2

d/ Items 1 to 8 plus 10, table III.2

e/ Items 1 to 8 plus 10, table III.2

f/ Item 1, table III.2

Table III.4. Cash flow statement for large power (75-200 MVA) transformers with an annual output of 10,000 MVA in Group I
(In thousand US dollars)

Year from start of operation	(3)	(2)	(1)	1	2	3	4	5	6	7	8	9	10
A. Fixed investment	(13 828)	(27 656)	(27 656)										
		(69 140)											
B. Cash outflow on:													
1. Materials				3 290	6 581	9 871	13 161	16 451	19 742	21 935	21 935	21 935	21 935
2. Wages and salaries				10 764	10 764	13 839	13 839	15 377	15 377	15 377	15 377	15 377	15 377
3. Utilities				900	1 350	1 800	2 250	2 700	3 000	3 000	3 000	3 000	3 000
4. Maintenance supplies for plant and equipment				1 484	1 484	1 484	1 484	1 484	1 484	1 484	1 484	1 484	1 484
5. Maintenance supplies for civil works				515	515	515	515	515	515	515	515	515	515
6. Running cost				263	525	788	1 050	1 313	1 575	1 750	1 750	1 750	1 750
7. Interest on working capital				190	381	573	764	955	1 146	1 273	1 273	1 273	1 273
8. Contingencies (5% of items 3 to 7)				168	213	258	303	348	386	401	401	401	401
Total B				17 574	21 813	29 128	33 366	39 143	43 225	45 735	45 735	45 735	45 735
C. Inflow through sales				10 500	21 000	31 500	42 000	52 500	63 000	70 000	70 000	70 000	70 000
D. Salvage value				-	-	-	-	-	-	-	-	-	15 115
E. (Outflow)/Inflow	(13 828)	(27 656)	(27 656)	(7 074)	813	2 372	8 634	13 357	19 775	24 265	24 265	24 265	39 380
		(69 140)											

Source: Joint ECWA/UNIDO Industry Division.

Table III.5. Cash flow statement for large power (75-200 MVA) transformers with an annual output of 10,000 MVA in Group II
(In thousand US dollars)

Year from start of operation	(3)	(2)	(1)	1	2	3	4	5	6	7	8	9	10
A. Fixed investment	(12 265)	(24 530)	(24 530)										
		(61 325)											
B. Cash outflow on:													
1. Materials				3 290	6 581	9 871	13 161	16 451	19 741	21 935	21 935	21 935	21 935
2. Wages and salaries				7 876	7 876	10 127	10 127	11 252	11 252	11 252	11 252	11 252	11 252
3. Utilities				600	900	1 200	1 500	1 800	2 000	2 000	2 000	2 000	2 000
4. Maintenance supplies for plant and equipment				1 429	1 429	1 429	1 429	1 429	1 429	1 429	1 429	1 429	1 429
5. Maintenance supplies for civil works				393	393	393	393	393	393	393	393	393	393
6. Running cost				263	525	788	1 050	1 313	1 575	1 750	1 750	1 750	1 750
7. Interest on working capital				178	357	536	714	893	1 071	1 190	1 190	1 190	1 190
8. Contingencies (5% of items 3 to 7)				143	180	217	254	291	323	338	338	338	338
Total B				14 172	18 241	24 561	28 628	33 822	37 784	40 287	40 287	40 287	40 287
C. Inflow through sales				10 500	21 000	31 500	42 000	52 500	63 000	70 000	70 000	70 000	70 000
D. Salvage value				-	-	-	-	-	-	-	-	-	12 265
E. (Outflow)/Inflow	(12 265)	(24 530)	(24 530)	(3 672)	2 759	6 939	13 372	16 678	25 216	29 713	29 713	29 713	41 978
		(61 325)											

Source: Joint ECWA/UNIDO Industry Division.

Table III.6. Discounted cash flow and rate of return for large-power (75-200 MVA) transformers with an annual output of 10,000 MVA in Group I (In thousand US dollars and per cent)

	Year from start of operation	Undiscounted amount	Compounded/Discounted at 7 per cent Factor	Compounded/Discounted at 7 per cent Value	Compounded/Discounted at 8 per cent Factor	Compounded/Discounted at 8 per cent Value
A. Outflows	(3)	(13 828)	1.2250	(16 940)	1.2597	(17 419)
	(2)	(27 656)	1.1449	(31 663)	1.1664	(32 258)
	(1)	(27 656)	1.0700	(29 592)	1.08	(29 868)
Total A	0	(69 140)		(78 195)		(79 545)
B. Net inflows	1	(7 074)	0.93000	(6 579)	0.92000	(6 508)
	2	(813)	0.86490	(703)	0.84640	(688)
	3	2 372	0.80436	1 908	0.77869	1 847
	4	8 634	0.74805	6 458	0.71639	6 185
	5	13 357	0.69569	9 292	0.65908	8 803
	6	19 775	0.64699	12 794	0.60636	11 991
	7	24 265	0.60170)	1.6817	0.55785)	1.5432
	8	24 265	0.55958}	x24 265	0.51322}	x25 265
	9	24 265	0.52041)	=40 806	0.47216	=37 445
	10	39 380	0.48398	19 059	0.43439	17 106
Total B		148 426		83 035		76 181

Average undiscounted rate of return (per cent) $= \frac{148\ 426 - 69\ 140}{69\ 140 \times 10} \times 100 = 11.5$

Internal rate of return (per cent) $= 7 + \frac{(83\ 035 - 78\ 195) \times (8 - 7)}{(83\ 035 - 78\ 195) + (79\ 545 - 76\ 181)} \times 100$

$= 7.6$

Payback period = 7.4 years

Source: Joint ECWA/UNIDO Industry Division.

Table III.7. Discounted cash flow and rate of return for large-power (75-200 MVA) transformers with an annual output of 10,000 MVA in Group II (In thousand US dollars and per cent)

	Year from start of operation	Undiscounted amount	Compounded/Discounted at 12 per cent Factor	Compounded/Discounted at 12 per cent Value	Compounded/Discounted at 13 per cent Factor	Compounded/Discounted at 13 per cent Value
A. Outflows	(3)	(12 265)	1.4049	(17 231)	1.4429	(17 697)
	(2)	(24 530)	1.2544	(30 770)	1.2769	(31 322)
	(1)	(24 530)	1.12	(27 474)	1.1300	(27 719)
Total A	0	(61 325)		(75 475)		(76 738)
B. Net inflows	1	(3 672)	0.88000	(3 231)	0.87000	(3 194)
	2	2 759	0.77440	2 136	0.75690	2 088
	3	6 939	0.68147	4 729	0.65850	4 729
	4	13 372	0.59970	8 019	0.57290	7 661
	5	16 678	0.52773	8 802	0.49842	8 313
	6	25 216	0.46440	11 710	0.43363	10 934
	7	29 713	0.40868)	1.08479	0.37725)	0.9910
	8	29 713	0.35963}	x 29713	0.32821}	x 29713
	9	29 713	0.31648)	=32 232	0.28554)	=29 446
	10	41 978	0.27850	11 691	0.24842	10 428
Total B		192 409		76 088		70 405

Average undiscounted rate of return (per cent) $= \frac{192\ 409 - 61\ 325}{61\ 325 \times 10} \times 100 = 21.4$

Internal rate of return (per cent) $12 + \frac{(76\ 088 - 75\ 475) \times (13-12)}{(76\ 088 - 75\ 475)+(76\ 738 - 70\ 405)} \times 100$

$= 12.1$

Payback period = 6 years

Source: Joint ECWA/UNIDO Industry Division.