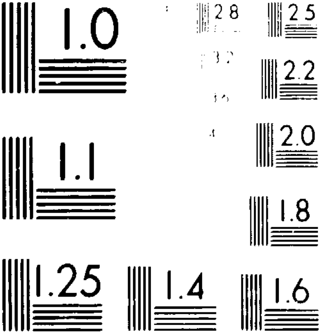
UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org



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ENERGY AND INDUSTRIALIZATION OF DEVELOPING COUNTRIES:
SOME OVERALL AND SECTORAL CONSIDERATIONS

Sectoral Working Paper Series

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SECTORAL WORKING PAPERS

During the course of work on major sectoral studies by UNIDO's Division for Industrial Studies, several working papers are produced by the Secretariat and by outside experts. Selected papers that are believed to be of interest to a wider audience are presented as Sectoral Working Papers. These papers are more exploratory and tentative than the sectoral studies. They are therefore subject to revision and modifications before incorporation into the sectoral studies.

Preface

The first version of this document was presented in 1982 at the request of the Special Advisory Group on Energy within UNIDO. It was used as background material for the UNIDO participation in the planning of the follow-up work to the United Nations Conference on New and Renewable Sources of Energy which was held in Nairobi in 1982. For this reason the report discusses also questions concerning total energy consumption and supply, industrial strategies and future requirements of energy for industry in addition to the sectoral perspective. The document has now been thoroughly revised. It is issued with the purpose to contribute to the understanding of the energy problems of developing countries, particularly in connexion with the concerted development of their industrial and energy sectors, and in order to highlight some of the results from recent studies on selected sectors of industry and to stimulate a discussion about the treatment of energy aspects in UNIDO's sectoral studies.

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1. Introduction

It is widely recognized nowadays that a real economic independence of developing countries can only be achieved through the creation of diversified industrial structures which will be capable of meeting the basic requirements of their economies and allow them to take an active and equal part in the international division of labour. Therefore, the industrialization process is a centrepiece in any development towards a new international economic order.

Whereas there is a widespread consensus, both in industrialized and in developing countries, on the role of industrialization in the development process, there is much less agreement on the strategies to be followed and the choice of industrialization patterns and sectoral composition of industry in developing countries. However, it is clear there can be no single model of the industrial structure for all developing countries; its concrete composition and proportions between various branches of industry for individual developing countries should be determined primarily by their natural resources with due account paid to the domestic economic structure, to the world context and to the possibilities of co-operation among developing countries on sub-regional, regional and regional and inter-regional levels. Subsequently, in recent years stress has been put on attempts to avoid a duplication of the industrialization patterns of developed countries through an indigenous industrialization based on processing and utilization of indigenous natural resources and adapted to local needs and prerequisites.

It is obvious that considerations of the supply and use of energy gain a special weight in the context of industrialization choice of industrialization strategies and sectoral distribution of industry. Furthermore, the efforts of developing countries to accelerate the progress of their industrialization coincide with substantial changes in the world energy situation when all countries reconsider their approaches to the problems of energy supply and consumption, undertake intensive measures to restructure existing energy balances in order to decrease their dependence on oil and to rationalize consumption of energy in all sectors of the economy. It is widely accepted now that the world has entered a transitional period from the use of exhaustible resources of energy to inexhaustible ones, the so-called new and renewable sources of energy.

One of the major topics of discussion in recent literature has been the question of how the energy sector in developing countries can learn to cope with the increasing pressure from the world energy markets. Lack of an adequate energy sector is now considered as an additional essential factor explaining the slow rate of growth of industrialization in developing countries[1/].

Industrialization requires an adequate energy base and at the same time it provides conditions for the development of the energy sector and leads to the expansion of energy use in all sectors of the economy. Thus energy aspects of developing countries' industrialization cover a broad range of issues and inter alia such important ones as:

- total primary energy requirements of the developing countries in the light of their industrialization target,
- prospects of meeting their future energy requirements which are to a considerable extent determined by the industrialization, and
- the interface between energy and industry and their interactions and
- energy aspects of different sectors of industry.

The present paper draws on other UNIDO papers such as "World Industry in 1980"[2/], "Energy Development and Industrialization" and "Industry and Development"[3/] and intends to consider some issues with particular reference

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1/ See e.g. Lammas, Prem S. and Martin Williams, "Energy and Economic Development", Weltwirtschaftliches Archiv, Bd. 117, 1981, Heft 4, pp. 706-716.

2/ "World Industry in 1980", UNIDO, ID/269, United Nations, New York, 1981.

3/ "Energy Development and Industrialization", UNIDO/OEA 135, 1982; "Industry and Development, No. 6, UNIDO, ID/SER. M/6, United Nations, New York, 1981.

to a number of branches of industry that are important from the industrialization point of view and allow to show some of the main characteristic features of industry/energy interactions. Inasmuch as the energy aspects of industrial branches are concerned, it reflects the results of the work which has been carried out in the sectorial studies at UNIDO so far in this field. At the same time, an attempt is made to draw some conclusions regarding elements of an integrated energy and industrialization policy as well as to identify main directions of the studying of sectoral and intersectoral energy aspects within the framework of sectoral studies in UNIDO.

2. Energy requirements of developing countries

2.1 Patterns of present commercial energy consumption

2.1.1 By source of energy and group of countries

Table 1 gives an overview of the structure of energy consumption by different groups of countries and by main sources of commercial energy and the changes between 1970 and 1980.

The share of developing countries in total world consumption of commercial energy is small (12%), but it grew relatively strong between 1970 and 1980. In absolute terms their consumption of commercial energy has nearly doubled in this period. Also in the centrally planned economies, energy consumption increased rapidly. Combined with modest increases in the developed market economy countries, these trends led to a decreasing share for the latter group from 64 per cent in 1970 to 56 per cent in 1980.

Developing countries and centrally planned economies show a relatively rapidly increasing per capita consumption of commercial energy. In 1980, however, in developed market economy countries it was still 13 times higher than in developing countries and 3 times higher than in centrally planned economies. More than the other regions, developing countries are dependent on oil (1980: 64%), whereas in the developed market economy countries oil plays a dominant but less important role (1980: 47.6%).

Table 1. Consumption of commercial energy
(total in mill, ton of oil equivalent)

		Solids total	in %	Liquids total	in %	Gas total	in %	Electricity total	in %	Total	in %	In kg of oil equivalent per capita
Developed market economies[a/]	1970	1,042	47.7[d/]	2,021	72.5	945	73.0	113	73.4	4,122	64.1	5,332
			25.3[e/]		48.1		22.9		2.7		100.0	
	1980	1,162	43.5	2,278	62.1	1,133	60.5	208	69.3	4,781	56.1	6,013
			24.3		47.6		23.7		4.4		100.0	
Developing market economies[b/]	1970	94	4.3	334	12.0	68	5.3	19	12.3	516	8.1	301
			18.2		64.9		13.2		3.7		100.0	
	1980	153	5.7	642	17.5	160	8.6	47	15.7	1,001	11.8	458
			15.3		64.0		16.0		4.7		100.0	
Centrally planned economies[c/]	1970	1,049	48.0	431	15.5	280	21.7	22	14.3	1,781	27.8	1,329
			58.9		24.2		15.7		1.2		100.0	
	1980	1,360	50.8	747	20.4	577	30.9	45	15.0	2,729	32.1	1,965
			49.9		27.4		21.1		1.6		100.0	
Total world	1970	2,186	100.0	2,787	100.0	1,293	100.0	155	100.0	6,409	100.0	1,753
			34.1		43.3		20.2		2.4		100.0	
	1980	2,671	100.0	3,667	100.0	1,870	100.0	300	100.0	8,511	100.0	1,947
			31.4		43.1		22.0		3.5		100.0	

Source: UN Statistical Yearbook, 1979/80.

a/ Comprises Developed Market Economies of Australia, Canada, Israel, Japan, New Zealand, South Africa, USA and Western Europe.

b/ Comprises Developing Market Economies of Africa, America, Middle East (including Turkey), Far East and Oceania

c/ Comprises Centrally Planned Economies of Asia and Europe.

d/ Vertical share: Share of the specific country group in world total.

e/ Horizontal share: Share of the specific kind of energy source in the total of country group.

Developed market economies and developing countries have reduced the share of liquids in their total energy consumption during the seventies, whereas the centrally planned economies have increased this share. Nevertheless, in these countries solids are the major energy sources in 1980 (49.9%).

Gas and electricity are of growing importance for all country groups.

The main problems for the developing countries are the heavy dependence on (imported) oil and the production of sufficient amounts of electricity for industrialization. The fact that most developing countries have to cover their oil consumption through imports adds to their financing and balance of payments problems.

In the process of development and especially of industrialization, the input of electricity becomes increasingly important. It can be expected that in the developing countries a growing share of primary energy will be used for the purpose of electricity production.

2.1.2 The share of industry and the importance of its different sectors

Industry is a major consumer of commercial energy in the developing countries. In the countries for which data are available, the industrial sector accounts for one fifth to two thirds of total commercial energy consumption with an average probably of around 35 per cent[4/]. Moreover, the industrialization process tends to increase the energy requirements.

The manufacturing sector in its turn is the major consumer of industrial energy. Information in most developing countries suggests that the manufacturing sector accounts for between 20 and 45 per cent of total energy consumption

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4/ "Finance and Development", December 1980, p. 12.

(see table 2). Obviously, the share of manufacturing in energy consumption varies not only according to its relative size in the total economy, but also according to the structure or composition of the manufacturing sector. Several factors determine the energy requirements, e.g. structural changes in favour of energy-intensive basic industries, increase in mechanization and automation of production processes, substitution of commercial for nor-commercial fuels, etc. Changes in the sectoral composition of production from light to heavy industries, constitute the main factor determining future energy intensity and growth of energy requirements along with the expansion of production itself.

Industrial branches such as chemicals, iron and steel, non-ferrous metals and pulp and paper, are industries consuming high amounts of energy per unit of value added. Table 3, however, shows the shares of developing and industrialized countries in 1977/79 in several sectors which are under continuous study in UNIDO. It can be seen that the respective shares of developing countries are particularly low in energy-intensive sectors such as iron and steel and non-ferrous metals. In the course of industrialization in developing countries, the share of heavy industry rises which means that the manufacturing sector as a whole becomes more energy-intensive and substantial increases of these shares will therefore have a considerable impact on the energy demand of developing countries.

The increasing demand for energy associated with the development of industrial sector and particularly of manufacturing constitutes the most essential part of the energy requirements of industrialization of developing countries. The another essential part of energy requirements is determined by the increasing consumption of energy in other sectors of economy as a result of industrialization.

Conseque .tly, future energy requirements of developing countries in the light of their industrialization are treated below in the context of the existing macro-economic projections.

Table 2. Share of the manufacturing sector in total energy consumption in selected developing countries, various years

Country	Percentage	Period
Algeria	...	
Argentina	...	
Brazil[a/]	40.9	1976
Colombia	38.5	1977
Costa Rica[a/]	13.5	1976
Ecuador	11.0	1977
Guatemala	15.9	1977
India[a/,c/]	64.9	1977-1978
Indonesia	...	
Iran	...	
Jamaica	48.8	1977
Jordan[a/,c/]	48.5	1977
Mexico	41.0	1977
Nicaragua	14.4	1976
Nigeria	...	
Peru	43.2	1976
Philippines[d/]	29.2	1973
Republic of Korea	35.7	1974
Saudi Arabia	...	
Suriname	33.8	1976
Thailand	...	
Turkey	27.7	1977
Uruguay	26.7	1977

Source: "World Industry in 1980", UNIDO, New York, 1981.

a/ All industry.

b/ 1967-1976.

c/ Electricity consumption only.

d Petroleum products only.

Table 3. **Share of country groups in total world manufacturing in selected industry sectors in 1977/1979**

ISIC	Industry sector	World total value added 1977/79 in constant (1975) (bill. US $)	Share in % of Developing[b] countries	Share in % of Industrialized countries
311/2 313	Food products and beverages	222.2	14.6	85.4
321	Textiles	94.8	16.2	83.8
323 324	Leather and leather products, footwear	23.3	9.4	90.6
331 332	Wood products and furniture and fixtures	66.1	5.6	94.4
351 352	Chemical products, including fertilizers and pharmaceuticals	175.2	10.3	89.7
353 354 355 356	Petrochemicals	105.9	17.8	82.2
369	Non-metal products (i.e. building material)	63.7	10.2	89.8
371	Iron and steel	99.4	8.4	91.6
372	Non-ferrous metals	35.3	6.8	93.2
382 383 384 385	Capital goods, including - agricultural machinery	602.8	4.9	95.1
314,322 341,342 361,362 381,390	Other manufacturing industries[a]	358.7	7.5	92.5
300	Total value added in world manufacturing	1,847.4	8.9	91.1

Source: **UNIDO Data Base.**

a/ 314 Tobacco; 322 Wearing Apparel; 341 Paper and products; 342 Printing, publishing; 361 Pottery, china, etc.; 362 Glass and products; 381 Metal products; 390 Other industries; 300 Total manufacturing

b/ Developing countries exclude China and a certain number of smaller countries.

c/ Industrialized countries exclude Albania.

2.2 Projections of future industrial development of developing countries and associated demand for energy

2.2.1 The Lima target and other projections

The goals of the international community for the industrialization of the developing countries are expressed in the Lima target, which was endorsed by the Second General Conference of UNIDO and calls for the developing countries' share of the world's manufacturing value added (in industrial production) to reach at least 25 per cent by the year 2000.[5/] The share in 1979 is estimated to have been around 10 per cent. If present trends in manufacturing production continue in both the developed and developing countries, the developing countries' share will reach only 14 per cent by the year 2000.[6/] Calculations based on UNIDO's LIDO model[7/] show that long-term GDP growth of the developing countries must run at about double the rate of the industrialized countries, if the Lima target is to be achieved.

Such a quantification makes it possible to make meaningful analyses also of the requirements of the industrialization of the developing countries, *inter alia* the requirements in terms of energy.

Table 4 shows one of the projections of manufacturing value added from the OECD's Interfutures[8/] project as well as a projection of historical trends and the LIDO-projection.

The Lima target applies only to manufacturing industry as a whole and is not sectorally disaggregated.

5/ UNIDO, ID/CONF.3/31, Chapter IV.

6/ UNIDO, "Industry 2000, New Perspectives", ID/CONF.4/3, 1979, p. 89.

7/ UNIDO, "Industry and Development", No. 6, New York, 1981.

8/ Interfutures, Facing the Future, OECD, Paris 1979.

Table 4. Projected development of manufacturing industry up to the year 2000

	Interfutures Scenario a/ (high growth)	Historical Growth b/	LIDO Projection c/
1. Annual growth in manufacturing value added (%)			
Industrialized countries	4.3	5.7	4
Developing countries	7.6	8.0	9
2. Share of developing countries by the year 2000 of world manufacturing value added (%)	16.4	13.9	25

a/ Interfutures, Facing the Future, OECD, Paris, 1979.
b/ UNIDO, "Industry 2000, New Perspectives", Vienna, 1979.
c/ UNIDO, "Industry and Development", No. 6, New York, 1981.

The Lima target such as it has been described above, can be attained only if certain specific requirements are fulfilled. It has been shown (see table 4) that a continuation of present trends, even under very favourable assumptions, will not be enough to achieve the industrialization target of the developing countries.

Recognizing the primary importance for developing countries to mobilize their indigenous resources and undertake every effort in this respect it is also necessary to say that new methods for increasing and facilitating the flows of technology, investment and finance will have to be developed. The markets of the industrialized countries must be opened up for industrial goods of developing countries and the international restructuring and redeployment processes must be accelerated and facilitated. The co-operation between the developing countries themselves must be promoted and turned into a cornerstone for the industrialization. The above mentioned requirements of the Lima target have been analysed in detail by UNIDO in other context.[9/]

9/ See e.g. UNIDO, Structural Changes in Industry, New York, 1981, and UNIDO, ID/B/261/Add.7, "Proposal for Setting Up an International Bank for Industrial Development".

The requirements in the field of energy availability are no less constraining than those alluded to above. The following sections contain a discussion of the energy dimensions of the Lima target, including some quantitative estimates of the energy requirements as well as some considerations of the possible supply of energy on an aggregated level.

2.2.2 A comparative estimation of the future energy demand

A UNIDO projection including both the growth implications of the Lima target and the respective magnitude of future demand for primary energy, as indicated in the table overleaf, shows that global demand for primary (commercial and non-commercial) energy would have to increase from 6,700 million tonnes of oil equivalent in 1975 to more than 16,700 million tonnes of oil equivalent by the year 2000.[10/]

Of this total, the requirements of the developed countries will grow from approximately 5,000 million tonnes of oil equivalent in 1975 to more than 10,000 million tonnes in 2000. The energy requirements of the developing countries estimated to be just above 1,600 million tonnes in 1975 would grow to nearly 6,500 million tonnes. This means that the share of the developing countries in commercial and non-commercial energy requirements would increase from 25 per cent to nearly 39 per cent.

The following table compares the Lima growth scenario of primary energy requirements with the OECD Interfutures high-growth scenario.

10/ "Industry and Development" No. 6, UNIDO, 1981 p. 32.

Table 5. Primary energy requirements by different groups of countries, 1975 and 2000 (commercial and non-commercial energy) (mill. tonnes of oil equivalent)

	1975	2000 Lima growth scenario	Interfutures (high growth scenario)
Developed countries	5,030	10,255	10,100
Developing countries	1,670	6,485	4,500
Total world	6,700	16,740	14,600

Source: UNIDO, Industry and Development No. 6, New York, 1981. OECD, Interfutures, Facing the Future, Paris, 1979.

The difference between the various scenarios are mainly due to the assumptions regarding future changes in economic growth and in energy elasticities. The Lima growth scenario of total primary energy requirements ranks high compared to the Interfutures high-growth scenario due to the higher economic growth rates in developing countries which are necessary in the LIDO scenario to attain the Lima target (c.f. also table 4.)

As far as the developed countries are concerned, the estimations of primary energy requirements do not differ very much between scenarios.

2.3 Prospects of meeting future demand for energy

Whereas it may be possible to make certain estimates of the energy resources required for the future industrialization of developing countries, it is considerably much more difficult to make corresponding projections of the supply, particularly with a break-down on various sources of energy. UNIDO estimates of the carrying capacity in relation to the Lima target seem to indicate that the energy reserves and the energy resources available, by themselves, would be large enough to allow for the predicted industrialization.11/ The restructuring, technological development and price structure which could be necessary to valorize these resources are, however, difficult to estimate. One overriding consideration, however, is that, according to many predictions and judgements, the oil reserves will be nearing exhaustion by the year 2000. In order to meet the requirements from the developing countries it is therefore necessary to diversify their sources of energy, to mobilize alternative sources of energy on a substantive scale. It was proposed in the United Nations Conference on New and Renewable Sources of Energy, in Nairobi, Kenya, that up to 50 per cent of the required increase of energy requirements of developing countries would be covered by new and renewable sources of energy. UNIDO estimates for the possibilities of developing such resources are presented in Table 6.

Among New and Renewable Sources of Energy (NRSE) only hydropower and biomass are likely to make significant contributions to the overall demand for energy from the industrial sector of developing countries on short and medium terms. Other NRSE are highly "location" or "purpose" specific and cannot be expected to make substantial contributions to the overall needs of developing countries. Evaluation of relative significance of NRSE for industry is presented in Table 7.

The following factors may have significant impact on meeting potential industrial energy requirements in the world and particularly in developing countries:

- Implementation of new energy policies
- Allocation of investment
- Training of personnel
- Structural changes in energy consumption patterns (substitution of crude oil)
- Changes in energy consuming technology

11/ UNIDO, Industry and Development No. 6, New York, 1981, p. 32.

- Development and application of new and renewable sources of energy in industry
- Problems of safety and nuclear proliferation
- Problems of social acceptance of energy systems
- Impact of increased energy consumption on climate and environment

Table 6. Estimate of NRSE for industry a/, b/, c/

G. US_{80}	1980	Factors	2000
Developing Countries			
GDP (G.US_{80})	2,200	7.3% (4.1x)	9,200
Industry (G.US_{80})	440	8.6% (5.2x)	2,300
(Share Industry/GDP)	20.1%		25.4%
Total energy (Mtoe)	1,700	7.0% (3.8x)	6,500
Energy for industry and transportation (Mtoe)	800	7.0% (3.8x)	3,000
Share of industry and transportation	46%	Share 46% d/	46%
Total energy covered by NRSE (Mtoe)	800		3,000
NRSE for industry and transportation	345	Share 43% d/	1,400
Share of various NRSE (in total energy balance)(Mtoe)			
Biomass (with fuelwood and charcoal)	660	3.0% (1.8x)	1,200
Hydropower e/	120	12.0% (9.6x)	1,200
Other f/	20	18.5% (30x)	600
Share of NRSE in industry (Mtoe)			
Biomass (with fuelwood and charcoal)			430
Hydropower			710
Other			260
Developed countries			
GDP (G. US_{80})	9,200	3.6%	19,600
Industry (G. US_{80})	2,800	3.8%	6,450

Source: UNIDO/OED.131.

a/ Industry and transportation.

b/ Figures are rough estimates and should all be rounded. The figures proposed correspond to certain scenarios and assumptions. They are consistent with the Lima target and with current models being used in UNIDO. Other scenarios and assumptions could be considered.

c/ To convert the figures in Mtoe into the equivalent installed hydropower capacity, divide by 1.25 (since 1 M.kW I.C. year = approx. 1.25 Mtoe).

d/ Share is higher if "non-commercial" energy is not considered.

e/ Estimates for 1980 changed, after the Expert Group Meeting on "Industrial Issues" (Vienna, January 1981).

f/ All other NRSE.

Table 7. Evaluation of relative significance of NRSE for industry[a/]

NRSE and order of magnitude of potential[e/]	Possible industrial uses	Approx. cost US $ electr. or mechan. purposes[c/]	kWh heating purposes[b/]
1. Large hydro (500-640 M. kW I.C.)	General urban and rural industries. Large energy-based industrial estates. Aluminium smelters. Urban transportation, railroad electrification.	0.020-0.030	same[d/]
2. Mini-hydro (50 M. kW. I.C.)	Small and/or rural industrial estates. Isolated medium and large scale industries	0.050-0.150	same
3. Biomass (including fuelwood, sawmill dust, charcoal and agrowastes (300 to 400 M. kW. I.C. or 360-480 Mtoe/year)	Already used widely for small and medium scale industries as fuelwood, charcoal based iron and steel industries, fuel alcohol automobiles, rural industries. (Great potential for further development and application in volume and diversity).		
4. Oilshale and tar sands (1.2 Mtoe/d by 2000? Or about 50 M. kW. I.C.)	Great potential but highly dependent on technological development. In principle, could be used competitively with petroleum but particularly important for: transportation (as fuel); resource based industrial estates; feedstocks for petrochemical industry.	0.070-0.100 (about same as petroleum based)	0.03-0.050
5. Geothermal (20 M. kW. I.C.) (?)	Small to medium sized industrial estates. Isolated industrial plants.	0.030-0.100	0.020-0.050
6. Wind (5 M. kW. I.C.) (?)	(Unstable discontinuous) Very small scale or "cottage" industries. Small agro-industries.	0.030-0.100	—
7. Other NRSE (5 M. kW. I.C.) (?)	Very small scale industries, small agro-industrial installation. Special use.		

Source: "Energy development and industrialization", UNIDO/OED.135, 1982

a/ Reference is made to table 19, page 43, of World Bank Report "Energy in Developing Countries" - August 1980

b/ Effective energy delivered to mechanical or electrical systems or for heating purposes. At 30% and 60% conversion efficiencies, respectively for fuel to effective energy.

c/ US dollars of 1980.

d/ Efficiency of conversion kWh to heat assumed at 100%.

e/ Estimated (rough) contribution in terms of power (kW) for actual use in industry (2000). (The unit used is the equivalent installed hydropower capacity, in M. kW. together with M.toe/yr.)

3. Energy/industry interface and some considerations on an integrated energy and industrialization policy

The interface between energy and industry is in the centre of the interest of UNIDO and of the present document. Industry is both an important consumer of energy and a producer of items which require energy for their utilization. Industry also produces the necessary equipment for the production of energy, exhaustible or renewable, conventional or not. The energy demand for the operation of the industrial sector as such represents a sizeable share of the total energy demand, i.e. about 35 per cent. However, the energy needed for the use of capital and consumer goods delivered by industry to other sectors of the economy amounts to another 50 per cent of total energy consumption. In other words, industrial activity is directly or indirectly responsible for the use of some 85 per cent of the total energy consumed in the world. Energy consumption and also energy efficiency can therefore be seen as mainly governed by the creativity and productivity of the industrial sector through the continuous technological development of energy-efficient processes and products.

UNIDO distinguishes in its work between three main aspects of the interaction described.[12/] These can be concisely referred to as: "energy for industry", "industry for energy" and "industrial energy management". They also correspond to three main goals of an integrated comprehensive and balanced industrial energy development programme. However, these concise headings cover a great deal of interrelated problems to be solved by developing countries in the course of the industrialization. One of such problems which is of a paramount importance for developing countries refers to the aspect "energy for industry" and has to do with the development of industrialization patterns appropriate to and consistent with the local patterns of energy availability, it includes development or adaptation of energy efficient and/or energy-appropriate processes and products; it will necessarily include non-conventional processes and products and it also

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12/ UNIDO Executive Director's Address to the U.N. Conference on New and Renewable Sources of Energy, Nairobi, Kenya, August 1981.

comprises full use of comparative advantages, such as the use of abundant and cheap hydropower for production of aluminium.

From table 8 alone it is clear that the energy intensity of different industries varies considerably. A study by the World Bank[13/] further shows, e.g. that also among basic products energy intensities range widely (for example, from 0.9 to 1.5 million kilocalories per ton for cement against 8 to 11 million kcal, including feedstock, per ton for ammonia). Energy intensities also differ depending on product mix, the type of energy source (electricity or hydrocarbon fuels), and the scale of plant as well as a variety of factors under the general heading of efficiency, such as the amount of waste heat, downtime, plant management and operating practices.

Table 8. Ratio of energy consumption to value added[a/], by manufacturing branch, in developing countries in the 1970s

Branch	ISIC	Median value
Food products	311	0.69
Beverages	313	0.50
Textiles	321	0.91
Wearing apparel	322	0.28
Paper and paper products	341	1.50
Printing and publishing	342	0.24
Chemical refining and miscellaneous products of petroleum and coal	351-354	0.76
Plastic products	356	0.64
Non-metallic mineral products	361-362,369	5.08
Iron and steel	371	1.37

Source: "World Industry in 1980", UNIDO, New York, 1981, p. 195.

a/ The ratios shown here are the share of each branch in total energy consumption by manufacturing divided by its share in total manufacturing value added. Owing to a lack of comparable data, the country sample includes only nine developing countries in the three developing regions.

13/ World Bank, Energy in the Developing Countries, Washington, 1980, p. 59.

Therefore, the choice of the industrial structure is of primary importance also for the energy economy of developing countries. It is usual in this context to talk about export promotion and import substitution strategies as examples of options which are available to developing countries. Whereas these strategies may lead to widely different industrial structures in different countries, it is nevertheless true that both of them somehow are influenced and governed by the external development over which the developing country does not have control. Even if the emerging structural pattern to some extent can be adapted to the specific advantages and preferences of the individual countries, these industrialization strategies will by necessity lead to a large amount of repetition of a pattern which is already established in other parts of the world. The indicators used for making investment decisions will be determined either by external demand or internal demand expressed by the more wealthy groups of society, at least initially.

The possibility of managing the energy requirements of such an industrial structure will depend inter alia on factors such as domestic energy availability, conservation policies and the possibility to acquire energy appropriate technologies for the industrialization process.

What has been said above does not of course imply that developing countries should abstain from such industrialization strategies or generally from investing in energy-intensive industries. In the final choice a total appraisal of the situation is necessary and considerations such as the comparative advantage conferred by the availability of natural resources, the degree of processing, the size of the domestic market, the possibility to earn foreign exchange to cover energy and other necessary imports and the cost of other inputs will be decisive.

There exist so far no full-fledged studies over the direct energy consequences for developing countries of choosing the one or the other industrialization strategy or a combination between them. Studies from industrialized countries, particularly such as were made around 1975, show, however, unequivocally that the branch mix, as generated by the demand structure, has a dominating impact on the energy requirement and energy dependence and the aspect of energy intensity is of main importance in designing structural policies.

Due attention should be given to the choice of technological processes to be used in developing countries from the energy point of view. For instance, a major opportunity exists for reducing electricity use in aluminium production by chosing the new Alcoa process instead of the predominant Hall-Heroult process widely used at the present time (from 8 Kwh to 4.5 Kwh per pound of aluminium).14/ Another example - direct reduction process for iron and steel industry - is of particular interest for developing countries, especially for those posessing natural gas reserves.

Many studies have shown that substantial amounts of energy can be saved at short term in industry at relatively little cost (even if these studies are, as a rule, based on conditions in industrialized countries). Table 9 shows, however, certain estimates of possible savings in industry in developing countries.

Energy saving measures, involving somewhat more investment and unique to the processes in the industry or plant concerned also exist. Building new plants or expanding existing ones offers even greater scope for improving energy efficiency, since the basic design can be chosen with this in view. Such housekeeping and saving measures could enable the developing countries to reduce their energy consumption per unit of industrial output by 10 per cent by 1985 and 15 per cent by 1990 according to the World Bank estimates.

Whereas energy saving measures are extremely important in the short run, over a longer period the most efficient reduction of energy consumption will be embodied in the technological development and in the development of the capital goods production, particularly energy-related equipment. This is why the opportunity to participate fully in the development of new and appropriate technology and to obtain equitable conditions in technology transfers are

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14/ G. Butcher, "Aluminium, the international perspective", published by Financial Times Business Information Ltd., London, 1982.

Table 9. Developing countries: possible savings in the major energy-intensive industries, 1980s

	Developing countries percentage of world production, 1978	Energy consumption per metric ton of output[a/]	Potential savings with existing plant (1978 production levels) Percent
Aluminium (from Alumina)	8.2	28-36	5-10
Copper (smelted and refined	22.3	3-8	5-10
Steel (crude)	8.1	4-6	5-10
Cement (clinker)	27.4	0.5-1.0 (fuel) 0.2-0.3 (electricity)	15-25
Ammonia	15.1	6-8	5-15
Petroleum refining			
Distillation	11.6	0.4	10-20
Cracking	6.9	0.7	10-20
Pulp and Paper	11.8	4-8	20-25

Source: "Energy in the Developing Countries", World Bank, August, 1980.

a/ Expressed in barrels of oil equivalent, assuming that 1 kWh of electricity input requires 2,670 kcal (10,600 Btu) of heat. This conversion factor varies widely depending on the type of primary energy, transmission losses, etc.

decisive also for the energy economy of the developing countries. An international restructuring involving the transfer of energy inefficient production processes and equipment would be counter-productive.

Even this brief consideration shows the importance of energy aspects in different branches of industry within the whole complex of issues on industry-energy relationship.

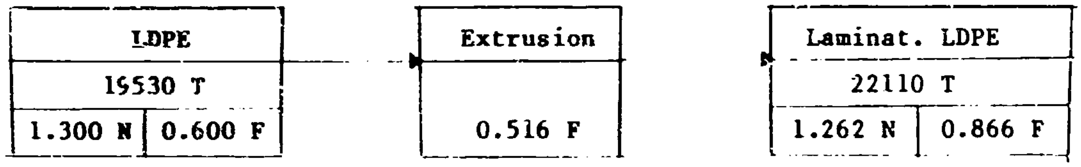
4. Energy aspects of selected industrial sectors

The energy aspects of different sectors of industry cover a variety of different problems. Such factors as consumption and supply of energy, energy conservation and self-sufficiency are of interest separately to each sector. There is, however, also a strong inter-relation between various sectors in the energy context. For example, PVC pipes, produced in the petrochemical industry by a very high energy consuming process, could replace in a number of cases iron pipes, which are produced in an even higher energy-intensive process. The capital goods industry, in itself only moderately energy-intensive, can have a large impact on the energy consumption in other sectors through the production of more energy-efficient equipment.

In the following some examples from recent sectoral studies on problems related to energy production, consumption, conservation and self-sufficiency are presented.

4.1 Energy consumption of the petrochemical industry and its impact on national energy saving

The petrochemical industry is a heavy energy-consuming industry. Moreover, being a hydrocarbon based industry the raw material used in the production process of petrochemicals is either liquid (oil and its products) or gaseous (natural gas or synthetic gas). In this respect, it is both a direct energy consumer as well as a consumer of raw materials used for the production of energy. In addition to this, the transformation of intermediate petrochemical products into final commodities ready for use is another heavy energy-consuming process. The following simplified example gives a good idea of the energy requirement of a typical petrochemical product.



where:

LDPE = Low Density Polyethylene

N = the energy consumed in the form of raw materials expressed in equivalent of naphtha in the European petrochemical industry.

F = the energy spent in the form of electricity, vapours and fuels over the various transformation steps. This energy expressed in fuel equivalent.

T = Kkal/kg.

The figure shows that for the production of one ton of LDPE and its conversion into laminated LDPE the total energy required would be 22100 Kal/kg. In spite of the fact that this is a very high energy consuming product, its average consumption of energy is nonetheless less than equivalent alternative products. For example, a 100 km long 4-inch PVC pipe with fittings consumes 360 tons of oil equivalent whereas the same length of cast iron pipe consumes 1970 tons of oil equivalent.

The bulk of energy used in the petrochemical industry is in the form of electric power or steam generation. As a result of the energy conservation measures to reduce cost it is expected that the energy/feedstock factor will be reduced substantially in this decade. However, the total energy consumption of the industry is expected to grow. The petrochemical industry consumed an average of 5-6 per cent of the total world energy consumption in the mid-seventies. This ratio is expected to rise to more than 12 per cent in 2000.

Energy conservation measures are very important for the petrochemical industry, a subject of tremendous research at present both at the process technology level and at the utility level, i.e. lowering the processing temperature and pressure, recycling of steam and process water, recycling of products, etc.

Products of the petrochemical industry are, moreover, playing an important role in energy conservation in other industrial and domestic areas. Improved home and industrial thermal insulation is one area where direct saving is immediately felt. Greater use of special plastics in the automotive industry to reduce weight is another example of reducing fuel consumption in this heavy energy-consuming sector.

4.2 Energy consumption in the iron and steel industry: the importance of technological developments and energy conservation measures

The iron and steel industry belongs to the highly energy-intensive sectors. It is estimated that 8-10 per cent of national energy consumption in developed countries is used in this industry. For individual countries this share is even higher, e.g. for Japan it is approximately 16 per cent[15/]. In many countries energy now constitutes a heavier cost burden in this branch than either for ferrous raw materials of for labour.

The fuel-energy balance sheet in the iron and steel industry includes the following types of energy: coal, fuel oil, gas and electricity. At present, coal accounts for the bulk of energy used in the industry.

Of the total amount of energy, used in the iron and steel industry, about 55 per cent is accounted for by coking coal, some 25 per cent by electricity and about 20 per cent by petroleum and natural gas[16/] (measured in calories).

15/ The energy situation in the iron and steel industry of Japan. ECE Seminar on the Energy Situation in the Iron and Steel Industry, Vienna, September 1981.

16/ The Economic Commission for Europe and Energy Conservation. Recent Experience and Prospects, United Nations, New York, 1980.

Production of pig-iron is the most energy-intensive production process within the iron and steel industry. It accounts for more than 50 per cent of energy used for the production of crude steel.

The close link between technology and energy consumption is a particularly important feature of the iron and steel industry since energy is used in various forms in each stage of any steel-making process. For example, coke is not only used for heating and smelting purposes in blast furnaces but at the same time serves as a basic chemical reagent for the reduction processes in the furnace and for carbonization of iron.

Consequently the structure of energy consumption and the levels of specific energy consumption per unit of final product in iron and steel making depend to a considerable extent on technologies used at various routes of production flow such as ore preparation, coke production, pig-iron production, steelmaking, rolling, etc.

The following technological processes are characteristic for the production of crude steel in developed countries:

1. coking - blast furnace (BF) - open hearth furnace (OHF)
2. coking - blast furnace (BF) - basic oxygen furnace (BOF)
3. direct reduction (DR) - electric arc furnace (EAF)

Open hearth steelmaking process is gradually disappearing from the steel-making scene.

The alternative basic oxygen steel-making process is at present prevailing in most countries of the world thanks to advantages with respect to, i.e. investment cost, productivity, steel quality and energy consumption. According to the ECE figures the oxygen converter process requires only 20 per cent of the energy needed in the open-hearth steel-making process[17/]. Open hearth steel-making has found only a very limited application in developing countries. Most of them with relatively new steel industries never built

17/ op. cit., page 60.

these old inefficient furnaces. Practically none have been built in the world for over ten years[18/].

However, both of these technological processes require large amounts of coke for production of pig-iron in blast furnaces. The current use of coke in the steel industry amounts to 2-11 per cent of the final energy requirements of the manufacturing activities in various world regions.

Since the majority of developing countries do not have any proven resources of coking coal they make efforts to develop cokeless production of steel. The 'direct reduction - electric arc furnace' steelmaking process is of primary interest for this group of countries. Although this process requires somewhat more energy than BF - BOF it has certain advantages for developing countries as many of them are well endowed by natural gas resources and have great potential for production of electrical energy. Cokeless processing has already found application in many developed and developing countries.

It can be seen from the brief overview of the development of the iron and steel industry in the world that energy being one of the major production factors has had a significant impact on the technological development of the industry. The technologies most widely used at present in the world iron and steel industry are less energy-intensive compared to the old ones.[19/]

Another important trend to be mentioned is that the iron and steel industry has been moving towards a diversified use of energy resources at different stages of the production flow.

18/ John E. Jankowski, Jr. Industrial Energy Demand and Conservation in Developing Countries. Discussion Paper D-73 A, Resources for the Future, Washington, 1981, p.

19/ The World Iron and Steel Industry (second study), UNIDO/ICIS, November 1978; Vienna. 1990 Scenarios for the Iron and Steel Industry (part one), UNIDO/IS 213/Rev. 2, December 1981, Vienna.

In addition to the energy conservation measures embodied in less energy-intensive technological processes (e.g. the use of BOF instead of OHF) the iron and steel industry has a great potential for energy saving through introduction of more energy-efficient equipment, housekeeping measures, etc.

Good housekeeping implies strict adherence to operating standards, efficient scheduling of materials and plant operation, monitoring of energy consumption, effective utilization of production capacities and a great number of other activities under the general heading 'plant management' which includes as well energy management.

Recovery and utilization of the waste heat in the iron and steel industry is one of the most important and efficient ways of energy conservation. Waste gas/heat recovery is given great attention in the iron and steel industries of many developed countries. Though there is still a big potential for further actions in this field, the results which have been already achieved in Japan, U.S.A., U.S.S.R. and other countries with highly developed iron and steel industry are rather impressive.

A broad introduction of equipment for waste-heat recovery and utilization in the iron and steel industry in the developing countries would significantly reduce energy consumption in this heavy energy-consuming industry.

4.3 Energy requirements and self-sufficiency of the mechanical wood-processing industries

The mechanical wood-processing industries are divided into the primary wood-processing industry, i.e. sawmilling, plywood and veneer production, particle board and fibreboard manufacturing, and the secondary wood-processing industry, which includes, among others, furniture, joinery and packaging.

Mechanical wood-processing industries are not as highly energy-intensive as the pulp and paper industry. Nevertheless, they have quite a large potential for energy substitution and conservation. Though it is difficult to find sufficient statistics for the energy consumption patterns of the mechanical wood-processing industries, particularly in developing countries, some information is available to show main characteristics of the industry from the energy point of view, including wood residues utilization as an internal source of energy.

The energy requirements in the mechanical wood-processing industries are:

- thermal energy (mainly for drying and heating purposes)

- electrical energy (for various types of electrical drives, lighting, etc.)

- motor fuel (for vehicles)

Energy requirements in primary processing of wood

The primary wood-processing industries are larger energy consumers than the secondary wood-processing industries. In addition to that, they produce significant quantities of residues which can be utilized for energy purposes.

Sawmilling is the least energy-intensive branch in the primary wood-processing industry. Kiln-drying accounts for up to 70 per cent of the energy consumption in sawmilling when it is used and uses major part of energy in the form of heat.[20/]

20/ The Economic Commission for Europe and Energy Conservation (Recent experience and prospects), E/ECE/985, UN, New York, 1980, p. 33.

The following annual energy requirements (electricity and thermal energy) are given for some typical sawmills:

Table 10. Annual energy requirements for sawmills of varying size

Production size m^3/year	Wood type	Kiln or no kiln	Energy requirements per year	
			MWh	GJ
3,000	S[a/]	k.	135	4,500
		n.k.	60	-
	H[b/]	k.	225	7,500
		n.k.	90	-
10,000	S	k.	450	15,000
		n.k.	200	-
	H	k.	750	25,000
		n.k.	300	-
5,000	S	k.	2,500	75,000
		n.k.	1,000	125,000
	H	k.	3,750	125,000
		n.k.	1,500	-

Source: Wood and wood-processing industry as a consumer and a supplier of energy. UNIDO, 1983.

a/ Softwood.
b/ Hardwood.

The figures given in table 10 show that there is a clear difference in energy consumption between processing softwood and hardwood. The processing of hardwood requires higher amounts of energy. A significant part of energy requirements is associated with the use of artificial drying. Depending on design and degree of heat recovery, a drying kiln has a consumption of thermal energy about (3.2-5) MJ/kg evaporated water.

If in sawmilling artificial drying is used when it is necessary in certain climatic conditions or to manufacture products of high quality, in plywood industry it is a natural part of the process in the production flow. Besides, the manufacturing of plywood requires considerable amounts of electrical energy for peeling, pressing, etc. and thermal energy for steaming and pressing. The following energy consumption is estimated per m^3 of produced plywood:

(a) softwood - 150 kWh of electrical energy and
4.0 GJ of thermal energy

(b) hardwood - 230 kWh of electrical energy and
6.0 GJ of thermal energy.

The principle for veneer manufacture is the same as that for plywood manufacture except the processing process. The energy consumption per m^3 of sliced veneer is estimated to be as follows:

(a) softwood - 110 kWh of electrical energy and
3.3 GJ of thermal energy

(b) hardwood - 170 kWh of electrical energy and
5.3 GJ of thermal energy.

Energy requirements in secondary wood-processing

For the furniture production, only wooden pieces of furniture are considered here with a raw material composition of 65 per cent sawn-timber and 35 per cent panel products. Examples of this kind of furniture are storage shelves, chairs and tables.

Energy requirements per ton of finished product for above mentioned types of production are for medium-sized and highly mechanized plants in Scandinavia estimated to be:

- electrical energy for processing - 250 kWh
- electrical energy for artificial drying - 100 kWh
- thermal energy for artificial drying - 4 GJ

Even in this case, the kiln is the biggest energy consumer.

For joinery production (doors, windows, etc.), the energy requirements are estimated as follows:

- electrical energy for processing - 200 kWh
- electrical energy for artificial drying - 60 kWh
- thermal energy for artificial drying - 2.4 GJ

Packaging covers boxes, pallets, crates, etc. These products are mainly made from sawn-timber. No further drying of normal sawn-timber is necessary. Thus this sector of wood-processing industry requires mainly electrical energy for equipment used in the production process.

Self-sufficiency in the wood-processing industry and wood-based energy production

The figures presented above give a general picture of energy requirements for various wood-processing industries. At present, energy requirements of the industry are mainly met by the basic energy supplies of coal, oil, natural gas and purchased electricity. Wood residues are also used by the industry for energy purposes but to a limited extent.

The current use of wood residues in the mechanical wood-processing industry in the world is not accounted for in any official statistics. However, for the primary wood-processing industries, it has been estimated to be about 87 million m^3 per year, while about 173 million m^3 per year find no industrial use.[21/] In the secondary wood-processing industry, it has been estimated that only about 15 million m^3 of sawn-timber and panel product residues are used, mostly for thermal energy purposes, out of a total available volume of about 64 million m^3 per year. Even these rough estimations clearly show the possibility for expanded use of wood-residues as an internal source of energy in the mechanical wood-processing industry.

21/ Wood and Wood-Processing Industry as a Consumer and a Supplier of Energy, Sectoral Studies Branch, UNIDO/IS, 1983.

Typically, the gross energy content of wood is as follows: 22/

Green-wood (50% moisture)	-	10,5 GJ/ton
Air-dry (20% moisture)	-	16,3 GJ/ton
Oven-dry (8% moisture)	-	19,8 GJ/ton

The utilization of wood residues for energy purposes in the wood-processing industry has recently gained a significant importance in many countries of the world. It may be of primary interest for developing countries facing severe national energy problems.

However, a review of the existing experience in this field worldwide and especially in developed countries shows that there are a number of problems associated with the utilization of wood residues for energy purposes. Solving some of them, such as e.g. development of environmentally acceptable and economically feasible technology for energy production from wood residues is of a common importance for all countries and is not linked in general to specific conditions of individual countries. Decisions on other problems such as ratios between volumes of wood residues to be used for energy purposes and as raw material, degree of energy self-sufficiency economically feasible for concrete plants may vary for different cases and should be taken with due account paid to specific conditions prevailing in individual countries.

The technology of wood-based energy production has a long history. Recent developments in this field have made equipment producing energy from wood more efficient and competitive to existing one using traditional commercial fuels. Though these developments have mainly taken place in developed countries, they apparently can be successfully applied in developing countries. Furthermore, it is possible to assume that many developing countries could develop manufacture and use similar equipment. The achievements of Brazil in charcoal making is well known. Another example is

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22/ L.P. White and L.G. Plaskett. Biomass as Fuel Academic C. Press, London, 1981, p. 112.

the development of a cyclon-type boiler which gives pollution free disposal of sawdust in Malaysia[23/].

4.4 <u>The capital goods sector as a producer of energy equipment producing and consuming energy</u>

Capital goods industries play a central role in energy/industry interrelations due to their contribution to the gross fixed capital formation in various sectors of the economy, to progressive technological changes, energy savings, to integration and independent development. The industry itself requires a moderate quantity of energy, particularly in its mechanical applications. Foundries and other heat applied sections of production are, however, very energy-intensive. More important the sector produces energy-related equipment for all other sectors of the economy.

The capital goods sector entails two quite distinct activities:

- the manufacture of machines, equipment, components and their assembly;
- preliminary studies, project and process engineering, design of machines and equipment and their technological development.

The first activity requires investments and training of manufacturing personnel which varies in accordance with the level of technological complexity of capital goods. The second requires a special investment in skilled manpower as designers, researchers, draftmen, calculating personnel, experienced production labour and extensive means information.

Entry of the developing countries into the production of energy-related capital goods passes through the progressive mastery of the three major

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23/ World Wood, February, 1982, p. 42.

components which are engineering, manufacture and R and D. It is possible to distinguish three principal stages which can be successively mastered by the developing countries.

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

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

The third stage comprises the manufacture of certain highly complex and strategic sub-assemblies which require very special techniques and, in certain cases, considerable know-how. The process engineering activity necessitates mastery of the design of capital goods, the R and D activity as well as the design activities associated with the production of all the equipment. This requires diverse and complex technologies and financial, technical and human resources if technological independence is to be achieved. Only some major producers have all these resources available. The entry of developing countries into this stage of production must therefore pass through technical co-operation with the major producers. This co-operation may be difficult to implement since the mastery of the know-how is a means for these companies to safeguard their position in international competition.

Capital goods for energy have to do with the development of a full technological and industrial capability of developing countries to produce a large spectrum of machinery and equipment and delivery of engineering services including maintenance for mining and production of conventional or non-renewable energy resources as well as NRSE as e.g. coal, gas, electrical energy, charcoal, fuel alcohol, geothermal, solar and windmill energy.

On the other hand, capital goods sector produces, innovates and develops new products (machines, equipment, implements, etc.) to fit not only local energy supply patterns including NRSE but to implement as well programmes aimed at more effective use of energy in industry and other economy sectors through introducing energy-saving technologies, capital, intermediate and consumer goods.

Some developing countries, particularly the more industrialized of these can manufacture most or all components of the above mentioned sectors and sub-sectors, others can carry out part of the maintenance and repair (routine and certain large repairs), produce some parts for imported equipment, and carry out only very preliminary studies and engineering development. Development of NRSE requires extraordinary efforts in the capital goods industries from both developed and developing countries. Entry into the manufacture of capital goods for energy including NRSE and other industrial sectors by developing countries due to its large variations in the technological complexity, can therefore be effected progressively by successive mastery of the technological production routes.

5. Conclusions

For developing countries industrialization is a base for up-grading living standards and for achieving real economic independence and is consequently one of the main prerequisites for establishing a new international economic order. The development of basic industries is an essential part of this process.

A successful industrialization process can not take place without an adequate energy base. Developing countries as a group have sufficient energy resources, but at a country level the situation is different. Many developing countries are poorly endowed with commercial energy resources or at least they have not discovered them yet. Besides, these countries have repeated to a considerable extent the production and energy consumption patterns of developed countries. As a result of that, oil has become a major commercial energy resource for the modern part of industrial sector in most developing countries. Drastic changes on the world energy scene during the seventies caused severe problems for oil importing developing countries and made it clear that without solving energy problems developing countries would not be able to attain their industrialization targets.

A comparative analysis of existing projections of future industrial development of developing countries and corresponding energy demand shows that the developing countries' energy requirements would rise more than three times by the year 2000.

The energy demand generated by the economic development implied by the Lima target requires a transition from the existing oil-based energy system, using energy, in a more or less extensive way, to a diversified system based on various energy resources and improving the efficiency of energy utilization. The stress should be made on the development of indigenous energy sources and on the energy co-operation between developing countries at subregional, regional and interregional levels. Coal and natural gas may be easily available as non-renewable sources of energy. Renewable energy sources such as hydropower and biomass have great potentials in developing countries and can make a significant contribution to the overall energy balance of the developing countries in the medium-term. The share of other renewable sources of energy (wind, solar, geothermal, etc.) in energy balances of developing countries is not expected to be high in the short and medium term but their expanded utilization may help ease energy problems of developing countries.

There is a strong overall interrelationship between energy and industry. Industry is both an important consumer of energy and a producer of items which require energy for their utilization. Industry also produces the necessary equipment for the production and distribution of energy, exhaustible or renewable, conventional or not. Therefore, creation of a local capability to develop, design and manufacture energy-related capital goods is of special importance for developing countries as well as obtaining an access to the world know-how in this field.

Another important requirement which has to be met in the course of industrialization by developing countries is the development of sound national energy economies carefully geared to the emerging structures of industry. This point is very important since industry is actually a mix of different kinds of production with specific requirements, particularly in terms of energy. On the other hand, the choice of industrial structure should be made with a due account paid to the availability of indigenous energy resources. It does not imply of course that developing countries which do not possess sufficient energy resources should abstain from the development of energy-intensive branches of industry which constitute a basis for the industrialization. In the final choice, a total appraisal of the situation is necessary and considerations such as the comparative advantage conferred by the availability of natural resources, the degree of processing, the size of the domestic market, the possibility to earn foreign exchange to cover energy and other necessary imports and the cost of other inputs are decisive. In this context, co-operation opportunities between developing countries could have a decisive influence.

At the industrial sector level, a great deal of attention should be paid to the choice of technological processes as well as to substitution and conservation measures. Building new plants or expanding existing ones offers a great scope for decision-makers in developing countries to develop various branches of industry taking advantage of indigenous energy resources and to achieve a rational energy utilization.

Access to detailed information on the energy aspects of various sectors of industry has a great significance for developing countries. Such information should cover a large number of issues related to the supply and use of energy in different sectors of industry. Some of these issues are of a common significance for all industrial sectors, others are more sector-specific. The following related issues should be given consideration for each sector:

<u>Energy requirements and supply</u>

- patterns of energy consumption
- trends in energy utilization
- impact of product mix on energy use
- changes in production processes and technology and their effect on energy consumption
- possibilities for use of indigenous fossil fuels
- possibilities for introduction of new and renewable sources of energy
- projections of energy supply and consumption

<u>Energy conservation and self-sufficiency</u>

- energy saving measures
- recycling of materials as a means of reducing energy use
- utilization of secondary energy resources
- utilization of production residues for energy purposes.

Energy-related equipment

- main characteristics of existing equipment
- trends in development of equipment
- possibilities and implication of its application for developing countries

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QUESTIONNAIRE

Energy and Industrialization of Developing Countries:
Some overall and sectoral Considerations

	(please check appropriate box) yes	no
(1) Were the data contained in the study useful?	/_7	/_7
(2) Was the analysis sound?	/_7	/_7
(3) Was the information provided new?	/_7	/_7
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