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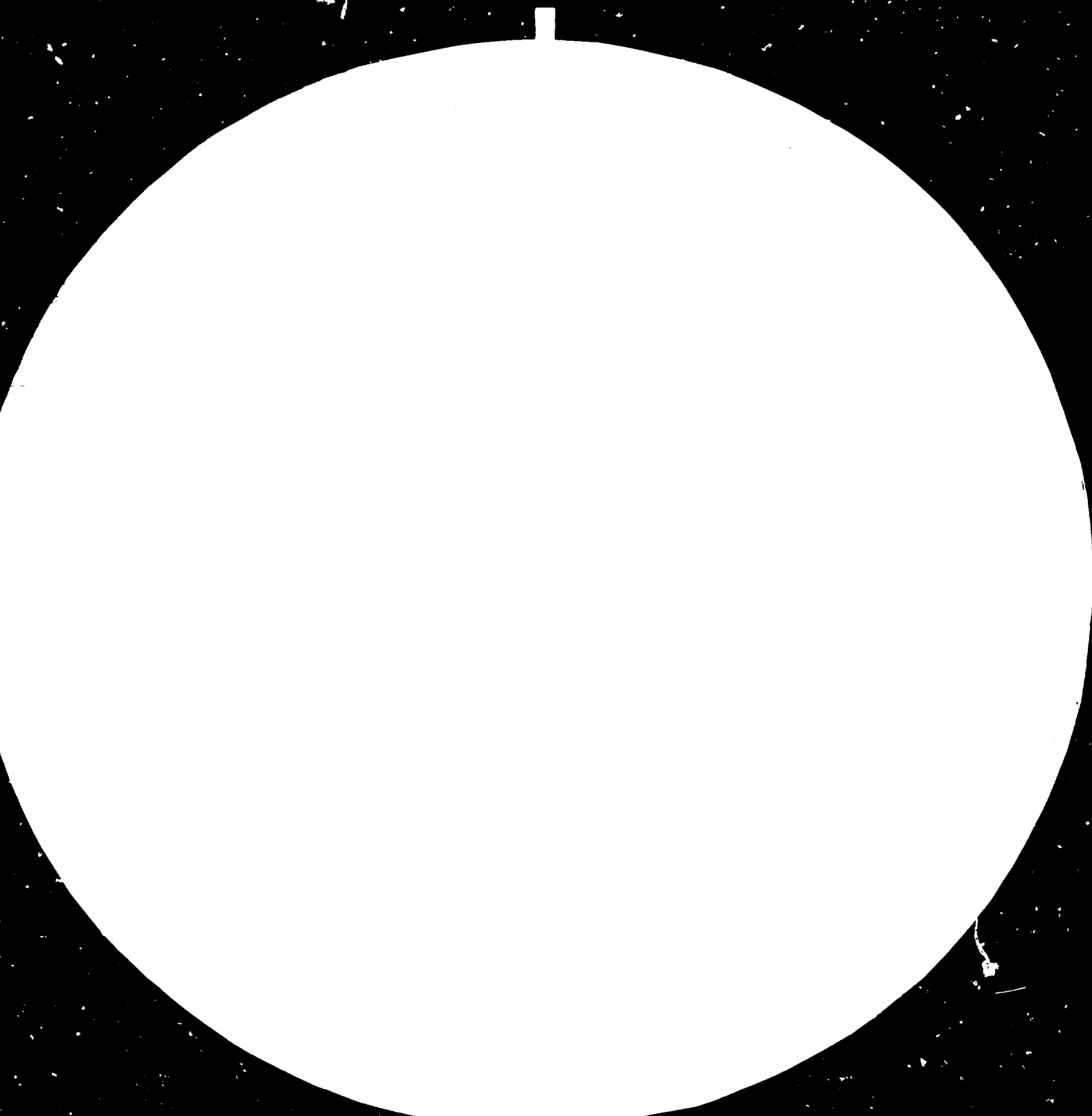

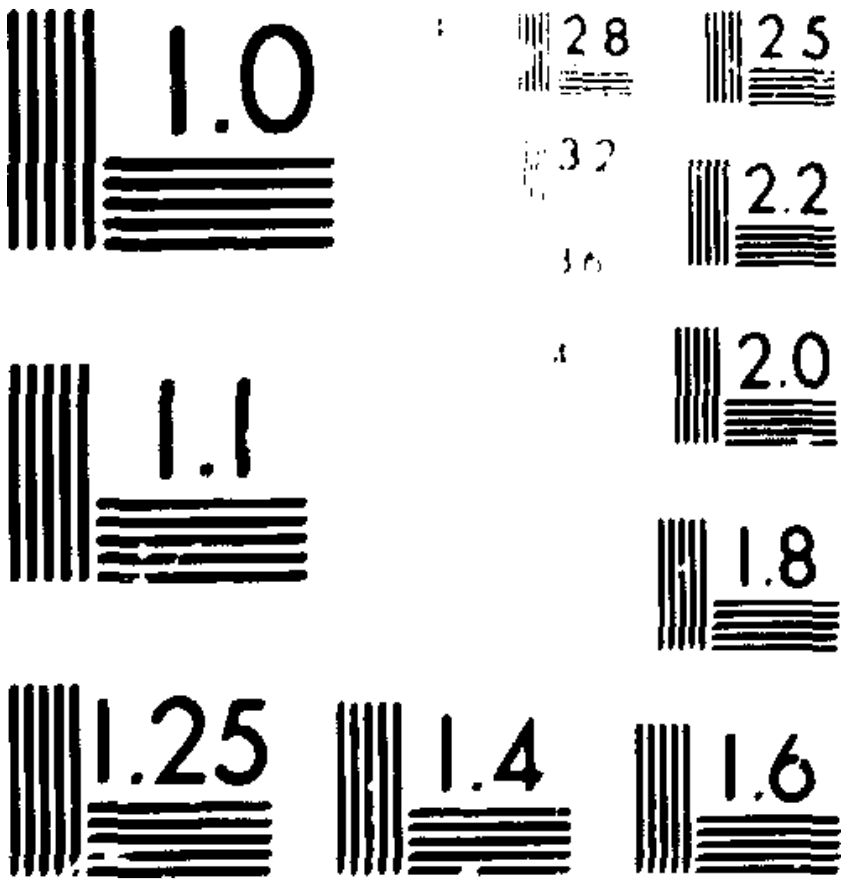

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NEW AND RENEWABLE ENERGY SOURCES AND INDUSTRIALIZATION*

Prepared by UNIDO for the
Ad-Hoc Expert Group Meeting on industrial issues,
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allied sectors
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The Scope of New and Renewable Energy Sources

1. The scope of new and renewable energy sources has been delineated by the Technical Panels of the Preparatory Committee for the United Nations Conference on New and Renewable Sources of Energy. From the interim reports of these Technical Panels new and renewable sources can be understood to include the following: 1/

- Hydropower: It includes micro-hydro power from plants of less than 0.1 MW and mini- hydro power from 0.1 to 1.0 MW.

- Oil shale and tar sands: Oil shales are fine grained elastic sedimentary rocks containing an organic material called Kerogen. Tar sands are materials such as sandstones, limestone or other sedimentary rocks containing oils with high viscosity under the underground conditions. Both, oil shale and tar sands belong to the class of unconventional petroleum resources.

- Fuelwood and charcoal

- Biomass energy: Biomass resources include standing vegetation, energy crops, agricultural and forest residues (manure, wheat and rice straw, maize stalks, bagasse, prunings, cuttings, bark and saw dust), municipal and industrial wastes and sewage sludge.

- Solar energy: Solar energy can be produced either by solar thermal technologies (passive systems, collectors, solar ponds) or by solar photovoltaic energy technologies.

- Geothermal energy: Energy produced from high and low temperature geothermal sources.

1/ Interim reports of the Technical Panels, Preparatory Committee for the United Nations Conference on New and Renewable Energy Sources; A/CONF.100/PC 5-12 from 7, 9, 16, 21, 22 and 23 May and 9 June 1980.

- Ocean energy: Energy production from the different energy potentials of the oceans such as ocean thermal energy, wave energy, tidal energy, salinity gradients, etc.

- Wind energy

2. This listing contains a variety of energy sources with widely different characteristics and potentials. First, renewable energy sources which have already a long tradition of commercial application such as hydropower are included. Second, energy sources which have always been used by mankind for energy purposes, but were not included among the usual commercial fuels, such as fuelwood are considered. Finally, truly new energy sources of the renewable (solar, ocean energy) and non-renewable type (oil shale and tar sands) are also included.

Global energy demand and the role of new and renewable energy resources

3. In order to put the current and potential role of new and renewable resources into perspective, an assessment of the current and future energy requirements and the contriubtions of the different energy sources must be made. Table 1 summarizes various estimates of the actual global energy demand - total and disaggregated by type of energy source - and gives some scenarios for the development of global energy demand until the year 2000. The commercial energy sources (oil, gas, coal, nuclear and hydroelectricity) are statistically well-documented, whereas for the non-commercial energy sources (fuelwood, charcoal etc.) relevant figures have been provided only in recent years in connexion with the last two World Energy Conferences (Istanbul 1977 and Munich 1980).

4. According to these estimates commercial energy requirements for the year 1976 are around 6,000 million tons of oil equivalent (MTOE) or 8,600 million tons of coal equivalent (MTCE). The latest estimate for non-commercial energy consumption has been provided by Frisch. According to these estimates non - commercial energy consumption in the world totalled 670 MTOE (or 960 MTCE), the greatest part being used in the Third World.

5. Currently, the first and the second of the previously mentioned three types of new and renewable energy sources - hydropower and fuelwood and other kinds of biomass energy - are being used. Hydropower contributes approximately 5% and fuel-wood, charcoal and other biomass energy around 10% to global primary energy requirements. 1/

6. Until the year 2000 global energy demand according to different scenarios is expected to expand by a factor of 2 to 3. The differences in these scenarios stem primarily from different assumptions about economic growth and the development of the relationship between energy demand and economic activity. Despite the variance of the projections and especially the different scenarios of each projection, it can be found that the range of 13 to 15,000 MTOE (or 18,500 to 21,500 MTCE) seems to be the one on which most analysts could agree as the most probable global energy demand by the year 2000.

7. The different types of new and renewable energy sources are expected to have quite different developments. The share of hydropower will remain more or less constant. 2/ The share of the other two types of new and renewable energy sources taken together would even decrease by a quarter. This is the result which is to be expected from two quite distinct developments. First, the use of the traditional renewable energy sources such as fuelwood, agricultural wastes will continue to grow although at a slower pace. This is primarily due to limited availability and concomitant substitution by the traditional commercial fuels. At the same time, the third type of the above types of new and renewable energy sources will expand rapidly but by the year 2000 will still have captured only a small share of the market. 3/

1/ According to a now-widely adopted convention 1 joule of electricity is considered equivalent to approximately 2.6 joule of fuels.

2/ In the cases of more rapid growth of total energy requirements the share of hydropower would even decrease slightly.

3/ So will for example the share of unconventional petroleum (oil shales, enhanced recovery, etc.) still be under 5% of total petroleum.

TABLE 1: WORLD PRIMARY ENERGY CONSUMPTION

Actual (various estimates) and projections for the year 2000 (alternative scenarios)
(in MTOE) [1]

Source	1972 (WEC)[2]	1975 (UN/Taylor)[3/4]	1976 (Frisch)[5]	1976 UN	Caltex[6]	2000 WEC-high[2]	WEC-low[2]	Goldemberg [7]
Oil	2,611	2,397	2,597	2,565	6,319	5,085	3,700	-
Gas	1,044	1,051	1,164	1,111	2,445	2,088	1,612	-
Coal	1,498	1,712	1,887	1,800	4,078	3,882	2,769	-
Nuclear	48	76	89	89	1,485	2,520	1,930	-
Hydro	318	319	321	319	869	772	772	-
Commercial energy	5.516	5,555	6,058	5,886	15,191	14,142	12,167	-
Other (biomass, solar, etc.)	590	(430)	680	-	-	1.294	999	-
Total (in MTOE)	6,106	(5,985)	6,738	-	-	15,436	13,166	20.204
Total commercial energy in (MTCE) [8]	7,880	7,934	8,654	8,409	21.701	20.203	17.381	-
Total (in MTCE)	8,723	8,550	9,626	-	-	22.051	18.809	28.863

1/ Million tons of oil equivalent
2/ Conservation Commission to the World Energy Conference 1977: World Energy - Looking Ahead to 2020 (1978)
World Energy Resources 1985 - 2020, Executive Summaries (1978)
3/ United Nations: World Energy Supplies 1973-1978, Statistical Papers, Series, Vol. 22. (1979)
4/ Taylor, T.B.: A preliminary Assessment of Solar Energy for World Wide Use (1980)
5/ Frisch, J.R. (World Energy Conference 1980): Third World Energy Horizons 2000 - 2020 (1980)
6/ Gerholm, T.R. (World Energy Conference 1980): Long Range Energy Demand, Problems and Perspectives (1980)
7/ Goldemberg J: Global Options for Short-Range Alternative Energy Systems (1980)
8/ Million tons of coal equivalent

Industrialization and the energy demand of developing countries

8. The assessment of the energy situation for the developing countries has been seriously tackled only in recent years. The major reason for the statistical uncertainty about energy use in developing countries is apart from institutional problems the fact that the non-commercial energy sources such as fuelwood, agricultural wastes etc. still play a prominent role in filling the energy needs of the Third World. A comprehensive survey of the the uses of all energy sources in developing countries has been made available only recently. 1/ According to this survey the total energy demand of the developing countries was 1670 MTOE (or 2380 MTCE) by 1973, of which nearly 36% or 590 MTOE (or 850 MTCE) were consumed by the centrally planned countries of Asia and 1070 MTOE (or 1530 MTCE) by the other developing countries. (Compare also tables 2 and 3).

9. The share of non-commercial energy sources which contributed more than one-half in 1960 was still around 35% of total demand. Excluding the centrally planned countries of Asia the share of these sources (fuelwood, wood-wastes, cereal straw, vegetal and animal wastes) amounted even to 42%. The share of hydropower is lower than in developed countries, which reflects the low state of using hydropower energy sources, especially in the centrally planned countries of Asia. 2/

10. The energy demand projections for the developing countries show even greater variance than the global demand projections. This is the consequence of the less reliable data situation for the base years of the projections, on the one hand and large differences concerning the economic development and the respective energy intensities for developing countries on the other. For the developing countries excluding the centrally planned countries of Asia the growth rates of energy demand up to the year 2000 implicitly or explicitly assumed in the various projections range from 3.0 to 6.0 %. 3/ The assumptions for the centrally planned countries of Asia fall in the range of 2.5 to 5.5%.

1/ Frisch, J.R., The Evolution of World Energy Consumption: a retrospect 1960 - 1976. (1980.)

2/ Actually if the centrally planned countries of Asia are excluded the share of hydropower is 5.5% which is above the world average.

3/ The historical growth rate of approximately 5.0% is often used but in most cases alternative scenarios with growth rates in the above stated range are also evaluated.

TABLE 2: DEVELOPING COUNTRIES PRIMARY ENERGY CONSUMPTION 1/

Actual (various estimates) and projections for the year 2000 (alternative scenarios)
(in MTOE)

Source	1972 (WEC)	1972 (WAES) 2/	1975 (UN)	1976 (Frisch)	2000 WEC-high	2000 WEC-low	2000 WAES-high	2000 WAES-low	2000 Frisch
Oil	386	302	341	362	1632	1138	1360	953	1370
Gas	68	54	69	85	235	143	428	315	405
Coal	118	71	84	111	316	232	225	192	233
Nuclear	-	1	1	59	278	200	223	155	197
Hydro	43	49	54				210	150	235
Commercial energy	616	475	549	617	673	489	2446	1764	2438
Other (biomass, solar etc) (new energies in brackets)	331	-	-	454			-	-	816 (121)
Total	947	-	-	1072	3138	2202	-	-	3254
Commercial energy (in MTCE)	880	679	784	881	-	-	3494	2520	3483
Total (in MTCE)	1353	-	-	1531	4483	3146	-	-	4640

1/ Excluding Centrally Planned Asia

2/ Workshop on Alternative Energy Strategies (WAES): Global Prospects 1985 - 2000 (1977)

TABLE 3: CENTRALLY PLANNED ASIA PRIMARY ENERGY CONSUMPTION

Actual (various estimates) and projections for the year 2000 (alternative scenarios)

(in MTOE)

Source	1972 (WEC)	1975 (UN)	1970 (Frisch)	2000 WEC-high	2000 WEC-low	2000 Frisch
Oil	-	69	74	-	-	478
Gas	-	3	4	-	-	57
Coal	-	347	371	-	-	1200
Nuclear	-	-	-	-	-	58
Hydro	-	13	12	-	-	35
Commercial energy	-	432	461	-	-	1828
Other (biomass, solar etc.) (new energies in brackets)	-	-	131	-	-	234 (37)
Total	522	-	593	1521	1022	2063
Commercial energy (in MTCE)	-	617	659	-	-	2611
Total in MTCE	746	-	847	2173	1460	2947

So generally it is assumed that the energy demand of developing countries will until 2000 increase by a factor of 3 to 5. Taking the latest projection with the most comprehensive coverage (compare paragraph 8) this implies that by the year 2000 the developing countries would consume 5,320 MTOE (or 7,600 MTCE), of which the centrally planned countries of Asia would have a share of 2,060 MTOE (or 2,950 MTCE).

11. As it was the case on the global scale the various new and renewable resources will show quite different development paths. Hydrowpower is expected to increase significantly faster than overall energy demand in the developing countries, whereas in the centrally planned economies of Asia the share of hydropower is even expected to decrease. The other traditional renewable energy sources will in all developing countries grow only at a very slow rate and will provide only one sixth of total primary energy requirements by the year 2000. This reflects primarily the already existing fuelwood crisis in developing countries. 1/ Truly new energy sources are expected to develop rapidly but by the year 2000 their share will still be only 3% of total energy demand.

12. Generally the above projections of the energy demand of developing countries by the year 2000 are based upon assumptions concerning the economic growth of developing countries, which either correspond to the historical GDP growth rates of the developing countries or imply relatively modest expectations concerning their future development potential. Typically GDP growth rates for the developing countries as a whole (excluding the centrally planned countries of Asia) between 4 and 6% are assumed. Given the generally accepted development targets this will simply be not enough. The Lima target stipulates that by the year 2000 at least 25% of the world manufacturing output should be produced by the developing countries. This implies that even with rather modest expectations concerning the economic growth in developed countries, high rates of GDP growth accompanied with significant structural changes must be achieved by the developing countries. In a normative scenario the GDP of developing countries from 1975 to 2000 must grow at an average rate of 7.3% in order to achieve the Lima target, while the developed countries are assumed to grow at

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1/ To give an indication of the dimensions of this fuelwood crisis it should be recalled that the forests of the developing countries are being consumed at an annual rate of 1.3%. Apart from the problems of deforestation this forces the populations of developing countries in many cases to switch to the burning of animal dung and crop residues thus depriving the soil of valuable nutrients.

a corresponding rate of 3.7%. [1] The required growth rates in order to achieve the Lima target are significantly higher than the ones used in all the projections of developing countries energy demand. This points to the fact that the commonly available demand projections seriously understate the energy requirements necessary to achieve the set goals of development for the Third World.

13 The second major factor influencing the future energy demand of the developing countries is the evolution of the relationship between economic activity and energy requirements. This relationship is analyzed by two concepts - the energy intensity of GDP and the elasticity of energy demand with respect to GDP. [2] [3] Analysis of the relationship of energy demand and economic development by both concepts point in the same direction. In the early stages of development the energy demand increases more than proportionately when compared with the economic growth rates.

Typically the development of energy intensity of GDP over time exhibits a hill-shaped pattern. In the earlier stages of development the more energy-intensive sectors of the economy (basic industries, utilities etc) grow more rapidly than the rest of the economy. Only in later stages of development will the less energy-intensive sectors (equipment goods industries, certain service sectors, etc) take the lead and thus contribute to the slow-down of the growth of energy demand. [4] A comparative evaluation of the energy demand of the last 15 years for developed and developing countries shows that only in the highly industrialized countries the energy intensity has started to

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1/ The respective growth rates for manufacturing value added in this scenario are 4.2% for the developed and 8.8% for the developing countries (excluding centrally planned countries of Asia).

2/ The energy intensity is defined as the energy requirements per unit of value added measured in constant prices (e.g. kg of oil equivalent per one dollar value added.

3/ The elasticity of energy demand with respect to GDP is defined as the (annual) relative change of energy demand (in %) divided by the (annual) relative change in GDP (in %). It is a dimensionless figure and in cases of increasing (decreasing) energy intensity it is larger (smaller) than unity.

4/ This product mix of GDP aspect is only one of the determinants of the energy demand and its development. Changes in the energy efficiency of industrial progress, life styles etc. do also exert a significant influence on the pattern of energy demand.

decline, whereas the industrializing countries of Southern Europe and nearly all the developing countries show rising energy intensities.

14. The projections for the energy demand of developing countries given in Tables 2 and 3 have implicit elastiticities of energy consumption with respect to GDP growth ranging from 0.75 to 1.2. In view of the above discussion the- explicit or implicit - application of elasticities, significantly below unity, as it was the case in the above described projection of energy demand of developing countries - becomes questionable. 1/ Summing up there are two arguments why the energy demand of developing countries (excluding the centrally planned countries of Asia) by the year 2000 in view of the development targets (Lima) should be higher than envisaged in the above projections.

a) developing countries must grow faster,

b) industrialization of the developing countries will at best imply only a slowly declining but in many cases rather increasing energy intensity of GDP for developing countries.

Alternative calculations taking these arguments into account lead to the result that even under optimistic conditions the energy demand of developing countries (excluding the centrally planned countries of Asia) by the year 2000 must be at least 4000 MTOE (or 5150 MTCE), if the objectives of development are to be achieved.

The energy requirements of industry and the transportation sector in developing countries 2/

15. The total energy demand can be further sub-divided into the following four main consuming aggregates: the energy (transformation) sector and the

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1/ This still holds true even when consideration is given to the fact that the traditional renewable fuels (fuelwood etc.) are used with an extremely low energy efficiency and that substitution by fuels which can be used more efficiently implies that the primary energy requirements will not grow as fast as the finally used energy.

2/ Excluding the centrally planned countries of Asia.

final consumers, households and services, transportation and industry. 1/ Here the latter two will receive special attention. Data on the sectorial composition of energy consumption in developing countries are scarce. The data from the two major sources, with a combined sample of 23 countries have been evaluated and extrapolated to the whole group of developing countries. 2/3/ According to these estimates 16% of the primary energy requirements are consumed by the transportation and about 24% by the industrial sectors of the developing countries.4/

16. On the average of the developing countries one sixth of the primary demand is consumed by the transportation sector. While the shares vary widely between different countries, the general tendency can be stated, that in the process of development the share of the transportation sector tends to increase. Typically in the developed market economies the share of transport lies in a range from 15 to 25%,5/ and for the more advanced developing countries similar proportions hold true. Generally for the entire Third World the share of the transportation sector is expected to rise to 20 to 25% by the year 2000.

More than 60% of the energy demand by the transportation sector in developing countries is accounted for by automobil transport (cars, buses and

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1/ The industrial sector includes mining, manufacturing and construction, but not the production/transformation of energy itself. The treatment of non-energetic uses of fuels is not unanimous, but at least the industrial feedstocks should be included among the industrial consumption.

2/ OECD/IEA - Workshop on Energy Data of Developing Countries (1978); Frisch, J.R. - Survey of the Long-Term Development of the Energy Demand of the LDCs (1980).

3/ The following 23 countries were included in the combined sample: Algeria, Argentina, Brazil, Chile, Colombia, Costa Rica, Egypt, India, Indonesia, Iran, Jamaica, Kenya, Republic of Korea, Mexico, Nigeria, Saudi Arabia, Singapur, Sri Lanka, Thailand, Trinidad and Tobago, Tunisia, Venezuela and Zambia.

4/ If the share of the transportation and the industry sector is expressed in terms of total final consumption rather than total primary energy requirements then the respective figures become 20 and 29%. These figures are consistent with the figures used by WAES for the developing countries, if the fact that WAES considered only the commercial energies and did not allocate the industrial feedstocks to industry is taken into account.

5/ In 1972 the average for the OECD region was about 22%.

trucks) and about a quarter by the more traditional transport systems, railways and shipping. In comparison to that automobile transport accounts for nearly three quarters of the energy demand for transportation in developing countries and the share of railways and shipping is below 10%.

Currently, the by far dominant energy source for transportation is oil and electricity is the only other source which is consumed in significant amounts. But, in both developed and developing countries, petroleum accounts for more than 90% of the energy demand.[1/] The major reasons for this "oil-dependency" should be seen in the currently still unique appropriateness of liquid (fossil) fuels to the available transport technology (combustion engine).

17. As it is the case in the developed countries, industry, especially a few energy-intensive manufactures such as the primary metals industries (e.g. iron and steel, aluminium, copper), the chemical and petrochemical industry (e.g. ammonia, fertilizers, basic chemicals), the fabrication of stone, glass and clay products (e.g. cement), paper and allied products and food and kindred products, is a major final consumer of energy. The shares of industry in total primary energy demand vary considerably both in developed and developing countries. In the highly industrialized countries of Europe, the industrial sector accounts for about 30% [1/] of primary energy demand, while the corresponding proportions are lower for the United States and considerably higher for Japan. In the developing countries the variance is still higher ranging from less than one-fifth to over a half. On the average for the group of developing countries the share is almost a quarter and is generally expected to rise strongly. While for the developed countries the share of industrial energy demand generally decreases as a result of both the structural changes in the economy as a whole and within the industrial sector itself and also due to the permanent increases of energy efficiency in the individual branches, it rises for all countries in their process of development, the main reason being of course the increasing role of manufacturing in total output. [2/]

1/ Or 40% of final energy demand.

2/ This holds true not only for the typical developing countries, but also for the newly industrializing countries in Southern Europe.

18. Most of the above listed energy intensive industries, which are also at the same time the major industrial consumers, belong to the group of basic product industries. In 1975 these industries had a share of 23% of the value added of the industry (including construction) in developing countries. 1/ At the same time their share in the industrial energy demand is estimated to be almost 60%. 2/ The bulk of this energy consumption is in turn made up by only two branches: the iron and steel industry and the chemical and petrochemical industry. 3/ Typically in developing countries these two sub-sectors alone account for between 40 and 60% of the total industrial energy consumption or roughly two-thirds of the basic products group.

19. The further development of the industrial energy demand of the developing countries has been assessed in the context of the above-mentioned normative Lima target scenario. Based upon on the estimated energy demand of total industry of developing countries by the year 1975 of 240 MTOE (or 340 MTCE) two variants were computed. The first assumed that no structural change within the manufacturing sector takes place and in the second variant the share of basic products in the manufacturing value added was lowered by 5 percentage points. It was furthermore assumed that the energy efficiency of the industry in developing countries would grow at an annual rate of 1.1%. 4/ While the value added of industry grows at 8.4% the industrial energy demand would grow in the first variant at an annual rate of 7.3% to 1370 MTOE (or 1960 MTCE) by the year 2000 and in the second variant at a rate of 7.0% to 1270 MTOE (or 1815 MTCE). If the total energy demand of developing countries by the year 2000 must amount, at least, to 4000 MTOE (or 5715 MTCE) if the Lima target is to be fulfilled, the share of industrial energy demand in total demand would increase from 24% to 34% in variant 1

1/ Or 30% of the manufacturing value added (MVA).

2/ Under basic products the following energy intensive industrial branches subsumed: primary metals industries, chemical and petro-chemical industries, fabrication of stone, glass and clay products, paper and allied products and non-energy mining. The estimate was arrived at by combining available figures for energy intensities from various sources for developed and developing countries and a corresponding structural breakdown of the manufacturing value added.

3/ Including industrial feedstocks.

4/ This assumption was justified by the fact that the energy efficiency of industry in developing countries is currently very low and that substantial improvements should therefore be possible. The assumed annual efficiency increase of 1.1% implies that by the year 2000 only 75% of the current requirements per unit of output will be needed by certain industrial processes. This figure corresponds rather well to the assumed efficiency gains for the industry in United States where for year 2010 the following percentages were determined: Aluminium 55-79%, Cement 60-75%, Chemicals 74-84%, Construction 58-73%, Food 66-86%, Glass 69-82%, Iron+Steel 72-83%, Paper 64-76%, Other Manufacturing 57-85%. (The National Academy of Sciences, Energy in Transition 1985-2000, (CONAES report; 1979)

and 32% in variant 2. 1/ 2/ The share of the energy intensive basic products industries remain virtually constant in variant 1 and declines to 53% in variant 2.

20. This calculation may help to illustrate several important aspects of a successful industrialization strategy for the developing countries:

- Achieving the Lima target implies that the industrial sector of the developing countries becomes the major consuming sector, with households and services being second.
- As an immediate consequence thereof the supply of energy must be appropriate to the needs of industry - and in view of their dominant position especially of the energy intensive industries - in their quantitative and qualitative dimension, i.e. it does not suffice to produce sufficient amounts of low-quality energy, but this energy must also be usable in the industrial processes as process heat or steam, mechanical power etc. The role of new and renewable resources must always be seen in this perspective.
- While it is of utmost importance especially for resource-poor countries that alternative industrialization strategies in which the energy intensive basic industries play a lesser role are pursued, for the entire group of developing countries this reduces the primary energy requirements only by some 5%. 3/ This calls for increased co-operation among developing countries ; where (energy) resource-poor and resource-rich countries can make full [illegible] their respective comparative advantages

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1/ Or 40 and 43% of total final energy consumption, excluding the energy (transformation) sector.

2/ More or less accidentally this corresponds to the increase in the share of industry which were projected by a number of developing countries for themselves (Compare Frisch, J.R., Survey of the Long-Term Development of the Energy Demand of the LDCs, op. cit.)

3/ A reduction of the share of basic goods industries in total manufacturing value added from 30% in 1975 to 25% in 2000 must be considered as in the light of the historical experiences of both developed and developing countries a quite remarkable structural change and it cannot be readily envisaged, that a "different" industrialization strategy could have an even stronger effect.

New and Renewable Energy Sources and the Industry and the Transportation Sector

21. New and renewable energy sources will have their impact upon transportation in two ways :

- The decentralized transportation system provided by automobile transport (cars, buses and trucks) will continue to be the dominant mode of transportation both in developed and developing countries. Since for the foreseeable future this transportation system will remain "liquid fuel dependent" for reasons of power, storage etc., partial motor fuel substitutes, such as alcohol fuels produced by fermentation from biomass (e.g. sugar cane, corn) will have their place. Some countries (especially Brazil) have already begun to use a mixture of gasoline and ethanol (gasohol) as fuel for motor vehicles. While the technical limit seems to be be a 1:3 ratio of ethanol to gasoline over which the performance of the engine becomes adversely affected, the current blends which contain 10 to 16% of ethanol can be used by petrol-engined cars without any modification. 1/ Apart from the disadvantages that one gallon of ethanol contains only two-thirds of the energy of one gallon of petrol, alcohol fuel has some highly desirable advantages (high octane rating, less pollutants, less inflammable). In countries with large amounts of biomass wastes such as Brazil the use of gasohol seems to be a viable alternative to use renewable resources and to save energy. 2/

- The possible increase in the share of public and urban transport either as a consequence of rising fuel costs or as a result of conscious policies in favour of transportation systems with a higher energy efficiency might imply a somewhat higher consumption of electricity; which in turn may be partly produced from hydropower

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1/ At a cost of 200 US$ current petrol-engines could even be modified to run on pure alcohol.

2/ According to stated plans by the mid-1980s the majority of cars in Brazil will run on a 20% gasohol fuel. Production plans for ethanol production by the year 1985 are between 4 and 8 billion of gallons. The entire programme might also create up to 135,000 jobs. (Source; The Economist, 18 August 1980).

or other new and renewable energy sources. But in view of the small share of electricity in the energy demand of the transportation sector this effect will be rather small. Still further off in the future lies the possibility of electrically powered vehicles, which shall not be discussed here.

22. If the impact of new and renewable sources of energy in the industrial demand for energy in the developing countries is to be assessed then besides the mere analysis of the quantity of energy required by industry a number of additional factors such as the required type and quality of energy for industrial processed, cost and other considerations have to be taken into account.

The major energy applications in industry are for the following groups of activities: space heating, process heat and steam and mechanical power.[1/] The assessment of the energy use in industry would call for detailed energy profiles of the different industrial sectors in developing countries. Due to the lack of such profiles inferences from the energy use pattern in the different industries in different countries must be made. Typically over 70% of the industrial energy applications are for industrial process heat and industrial process steam. Especially in the primary metals industries,[2/] but also i the stone, glass and clay industries and the fabrication of food and kindred products is the ratio of technical heat to mechanical power especially high. Yet within this group of industries the variance of the quality of energy required is still high with respect to such factors as temperature and pressure.

Although the different energy sources are used for various industrial applications (e.g. electricity for electrolysis and mechnical power; fossil fuels for the production of process heat and stean, but also to a certain extent for mechanical power) there exists a correspondence between the relative shares of the different energy sources and the relative weights of the actual industrial applications. The share of electricity in industrial energy consumption which in many cases corresponds roughly to the mechnical

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1/ Here industrial feedstocks are excluded because their relative weight depends crucially upon the product mix of the chemical and petrochemical industry and varies greatly from country to country. On the average for developing countries industrial feedstocks can be assumed to account for approximately one sixth of the total industrial energy demand with a slowly rising tendency.

2/ Electrolysis is included here under process heat.

power applications, is on the industrial average in most cases still below 20%, despite a continuous increase of the share of electricity. 1/ In the developing countries the share of energy is still considerably lower and by the year 2000 electricity is expected to have a share between 15 and 20%.

23. The industrial energy profiles have to be contrasted with the quantities and types of energy provided by the various new and renewable energy sources. Only if the industrial need for a stable energy supply of the appropriate specifications is fulfilled can new and renewable energy sources be expected to play a significant role in the industrial energy consumption. The following Table 4 characterises the new and renewable energy sources, with the exception of hydropower, 2/ according to the level of technology embodied, the state of development and a number of other criteria. In Table 5 are these new and renewable energy sources matched with different fields of applications in the industrial and other sectors. It can be readily seen that some of the currently already practically available technologies such as fuelwood burning and solar stationary collectors have limited applications in the industrial sector. Wind energy which in this rating has a rather medium position, as in a number of industrial applications it seems to be quite feasible, is equally as the non-included geothermal energy in the overall picture of lesser relevance and should have rather local importance. The advanced bio conversion and also the more advanced solar technologies (solar ponds, solar concentrators and solar photovoltaics) seemingly have a greater potential for industrial application. Their specific drawback is yet the fact that they are mostly high technologies, which are also mostly still in the state of development. This and the required investment needs should make these technologies only to a certain extent realistic routes to a future energy supply strategy for the developing countries.

1/ This relation varies of course considerably in different industries and for the aluminium production the share of electricity (mainly for electrolysis) is over 50%, but also the chemical and petrochemical industry (excluding feedstocks) has high electricity shares. It should further be noted that taking account of on-plant generation might raise the share of electricity (in final consumption) to a certain degree.

2/ Hydropower has to be considered such a well developed and applied technology that the technology evaluation for its industrial applications and an assessment of its effects upon the industrial structure of a country (e.g. the strong influence on the site of aluminium processing as exemplified by the non-bauxite countries Canada and Norway and in the future possibly some developing countries with ample hydro-resources) do not need to be stressed any more.

Table 4: Characteristics of New and Renewable Energy Sources

	BIO-CONVERSION		SOLAR ENERGY				OCEAN ENERGY	WIND ENERGY
	Wood Burning	Advanced	Stationary Collectors	Solar Ponds	Thermal Single and Dual Axis Concentrators	Photo Voltaics		
1. Technology	Low	Intermed. to High	Intermed.	Intermed.	Intermed.	High	High	Low to High
2. State of Development	Ready	R and D Stage	Ready	R and D Stage	Tech. Ready to R and D	Tech. Ready	R and D Stage	Ready
3. Fossil Fuel Displacement Potential								
a) Developed Countries	Medium	Medium	Large	Medium	Large	Large	Large	Large
b) Developing Countries	Medium	Variable	Large	Medium	Med. to Large	Large	Large	Large
4. Cost Competitiveness								
a) Developed Countries	Good	Good	Marginal	Good	Variable	?	Fair	Good
b) Developing Countries	Good	Good	Fair to Good	Excellent	Good	?	Poor	Good
5. Local Production								
a) Developed Countries	Excellent	Good	Good	Very Good	Good	Good	Good	Very Good
b) Developing Countries	Very Good	Good	Good	Good	Fair to Good	Fair	Poor	Good
6. R and D Development Priority								
a) Developed Countries	Low	High	Medium	High	Med. to High	High	Medium	High
b) Developing Countries	High	Medium	High	High	Medium	Medium	Low	High
7. Financing Potential	Good	Good	Variable	Good	Fair	Fair to Good	Poor to Fair	Good

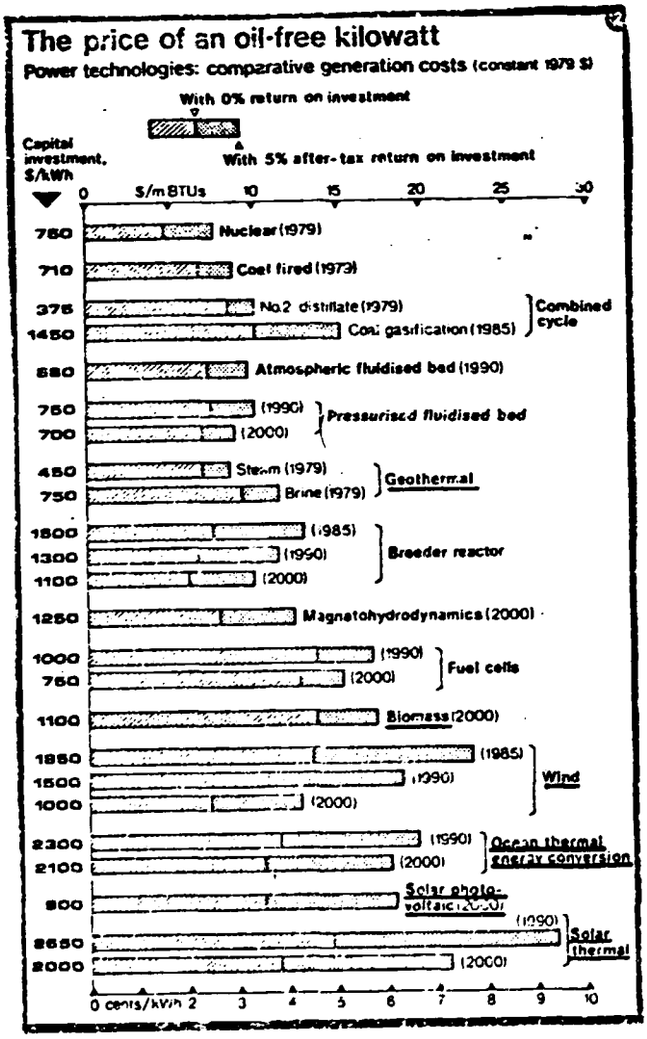
Source: Gupta L., Solar Energy For Development: Some Basic Issues (1980)

Table 5: Technology Application Matrix for New and Renewable Energy Sources

Sector (Application)	BIO-CONVERSION		SOLAR ENERGY				OCEAN ENERGY	WIND ENERGY
	Wood Burning	Advanced	Stationary Collectors	Solar Ponds	Thermal Single and Dual Axis Concentrators	Photo Voltaics		
1. Residential (Hot Water and Space Heating)	x	-	x	x	x	-	-	-
2. Residential (cooking)	x	x	-	x	x	-	-	-
3. Industrial/ Agriculture Crop Drying	x	-	x	-	x	-	-	-
4. Industry (Process Heat)	-	x	x	x	x	-	-	-
5. Industry (Process Steam)	-	x	-	x	x	-	-	-
6. Industry/Transportation (Mechanical Power)	-	x	-	x	x	x	-	x
7. Industry/Residential (Refrigeration)	-	x	-	x	x	x	x	x
8. Industry/Residential (Space Cooling)	-	x	x	x	x	x	-	x
9. Other (Electrical Power)	-	x	-	x	x	x	x	x

Source: Gupta L., Solar Energy for Development: Some Basic Issues (1980)

24. In view of its flexibility in application and its high end use efficiency electricity must be considered as a special high-quality form of energy. Therefore the production of electricity by new and renewable energy source will have its ramifications in all sectors of the economy and in the industrial sector as well. The major question will here not be a specific suitability for a certain industrial process, but rather simply the cost at which one KWh can be produced. The following graph shows a recent estimate of the comparative costs of alternative ways of producing electricity.



Source: Bechtel Corporation (The Economist, 6 October 1979).

According to this survey the new and renewable energy sources with the exception of geothermal energy do not appear to be cost competitive in electricity production in the immediate future and further technological developments or changing economic might be necessary to bring about a more rapid introduction of these technologies. Even when these estimates which have been prepared for a developed country, will have to be modified for developing countries and taking the fact that the traditional (especially small scale) electricity production in developing countries is quite costly in many instances into account, this does not change the overall picutre which points to a slow adoption of these technologies.

Conclusion

25. While at least under current circumstances the bulk of the energy requirements of industry will have to come from the traditional commercial fuels and new and renewable energy sources on the general level will have to play a lesser role (always with the exception of hydropower) these energy sources still are of importance in the process of industrialization. The most important aspects in this context are:

- In a number of specific instances (e.g. the use of wastes in the fabrication of food and kindred products, the use of process wastes in the pulp and paper industry, the different uses of solar energy in food treatment, 1/ etc.) will new and renewable energy sources be of considerable relevance.
- Especially in the cases of rural development problems where centralized energy supply would be inefficient. the use of new and renewable energy sources when properly adjusted to the local conditions could provide the most efficient way of supplying agriculture, households, but also local industries and handicrafts with energy.

1/ Compare Fazzalare R.A./ Smith B.G. - Changing Energy Futures, Vol. IV (1979)

- Generally new and renewable energy sources can be used to cater for the needs of households, services and agriculture which can apply lower quality energy. Higher quality energy could thus be released for use in industrial and other sectors. Energy would thus be used in a more rational manner.

- Currently most new and renewable energy sources require high technologies, in terms of capital, R and D and qualified manpower. By accelerating development of these technologies to the greatest economically feasible extent, developed countries could improve their own energy balances. Moreover, they would be able to release part of the needed traditional commercial energy sources for the industrialization of the developing countries and create a stock of know-how and experience from which the developing countries could draw to sustain their development in the future.