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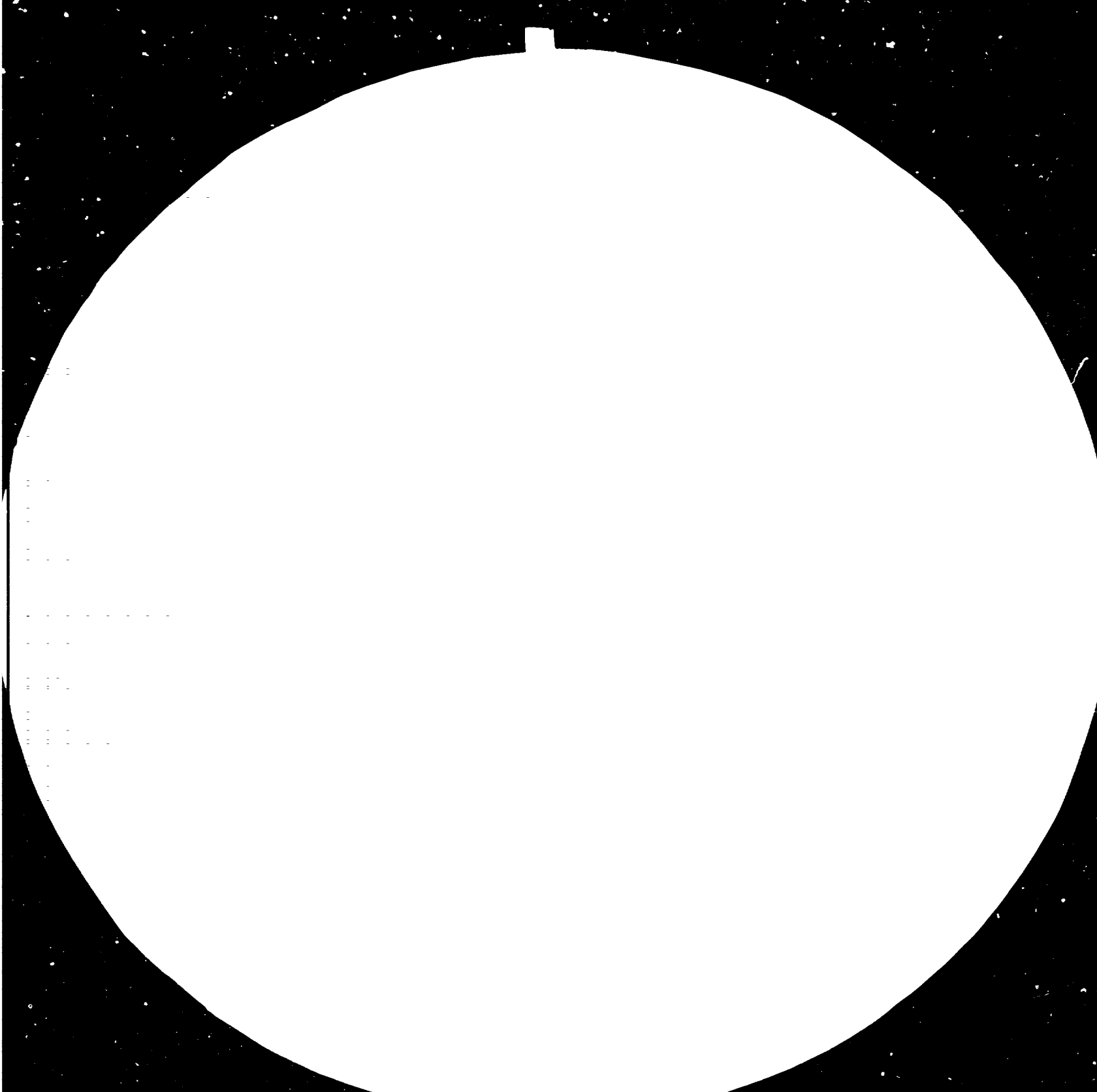

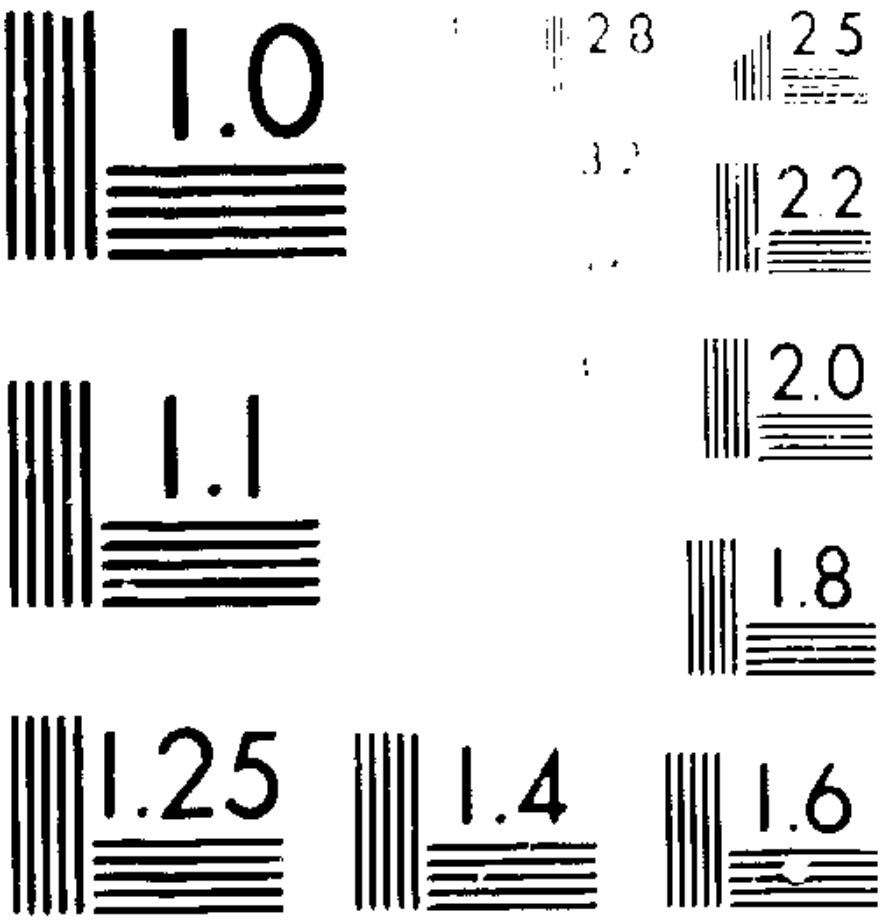
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Biomass/Hydro Taxonomy for Developing Countries

prepared by

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May 25, 1983

UNIDO

CONTRACT #CLT/83-139

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Biomass/Hydro Taxonomy for Developing Countries

Under the terms of reference of contract CLT/83-139, a taxonomy is to be prepared based on the following:

1. Potential for hydro-electric power;
2. Potential for biomass energy;
3. Distinguishes between those which currently do and those which do not have fuelwood problems;
4. Defines current situation with regard to oil relative to commercial fuel demand by indicating percentage of imports or identification as an exporter

The taxonomy is presented in Table 1.

Potential hydroelectric resources are indicated on the horizontal axis and theoretical biomass resources on the vertical axis. Countries with a fuelwood problem are marked with an asterisk. Within each category, countries are grouped according to whether they are net energy (in practice oil) exporters or importers. The importers are further disaggregated into three categories--countries where energy imports account from 0 to 25 percent, 26 to 75 percent, and over 76 percent of total commercial energy consumption.

Table 2 gives the data upon which the taxonomy is based, plus additional information on fossil fuel reserves and oil import bills, including detailed notes on the sources and derivation of the data. The following should be bourne in mind in interpretating the data.

1. The list of countries chosen are those defined by the World Bank as low income and middle income economies in, for example, the World Development Report Series. (These exclude high income oil exporters, industrial market economies, and non-market industrial economies). Out of a total of 96 low and middle income economies (see table 2), data are available for the 67 appearing in table 1.

2. Both hydroeletric and biomass resouces are expressed (in tons oil equivalent per capita) on an annualized output basis. That is, the data are measures of production which could be yielded by the resource base.

3. The resource concepts underlying the annualized production data in table 1 are rather different. The hydro data are based on installed and installable capacity. The biomass data are a measure of the potential energy that might be extracted from annual forest growth and crop and animal wastes, and are, in concept, more theoretical than the hydro estimates. In neither case is economic feasibility taken into account (although the hydro estimates do, of course, include already installed capacity). For information, data on total fossil fuels and oil proven reserves are given in table 2. Note that these reserves are proven and not potential or theoretical as in the case of hydro and biomass.

4. A fuelwood problem country is defined as a country in which estimated annual consumption of fuelwood could not be sustained through the end of the century without damage to the ecology. The estimated annual consumption is based on income level such that estimated consumption falls as GNP per capita rises. Countries above a certain per capita level of income ($900 U.S.) are assumed, because of their relatively high level of income, not to have a fuelwood problem. For information, data on GNP per capita is given in table 2.

5. Table 1 data on import dependency relates imports of total energy to total consumption of commercial energy (i.e. oil, gas, coal, and electricity--for this purpose fuelwood is not considered a commercial source of energy). Virtually all imported energy consists of oil. For information, table 2 contains data on countries' oil bills expressed as the value of oil imports as a percentage of total merchandise exports. The pre-1980 data (usually 1978 or 1979) are actuals. The 1980 data are estimates in which the actual results derived from countries for which data are available are extrapolated to countries for which post-1979 data are still not available.

The countries are categorized according to their hydro and biomass

resource endowments. In the case of hydro the three categories are:

1. under 0.25 tons oil equivalent per capita annualized production
2. between 0.26 toe and 1.1 toe
3. over 1.1 toe

For biomass the categories are:

1. under 0.5 toe per capita annualized yield
2. between 0.6 and 2.0 toe
3. over 2.0 toe

Tables 3 and 4 give the frequency distributions for hydro and biomass. These indicated in both cases some discontinuity at the top end of the range which suggested the cut-off points of 2 toe per capita for biomass and 1.1 toe for hydro. At the lower end of the range there was no clear division and the cut-off points were established arbitrarily at 0.5 for biomass and 0.25 for hydro. As a point of reference total (i.e. commercial plus traditional) energy consumption per capita in a wide range of developing countries is around 0.5 toe annually (the Latin American countries are substantially higher at about 1 toe). The upper bound of the lower biomass category therefore is set at about current per capita annual consumption of all energy. The electricity is lower (at .25 toe) although this would be substantially above present rates of electricity consumption (perhaps about 0.05 toe a year). The three categories should therefore not be automatically equated to low, medium and high on an absolute basis because even the "low" countries possess substantial resources as defined here. Furthermore, absence of data may imply low resources, so that the countries not included here, because of lack of data, may in reality be the truly resource poor countries.

This taxonomy does not lend itself to strong conclusions, but some interesting points emerge.

1. Most countries (all but 10 out of the total 67) are clustered in two categories of resource endowment. This clustering is due to the fact that per capita biomass and hydro-potential are to some extent influenced by the same factors, including land area, climatic zone and population. Few countries have a high potential for one with a low potential for the other.

2. These two categories are "low" and "medium" resource endowment.

However, it must be again emphasized that even the low categories are quite high in terms of current consumption levels. Almost all these countries have significant potential for biomass and hydro development, although cost and other factors need to be taken into account before a more realistic assessment of development potential can be made.

3. Fuelwood problems are widespread and distributed over all categories, including those with high biomass potential. This emphasizes the gap between the actual and the potential biomass situation and suggests that strong efforts will be needed to achieve this potential.

4. Many of these countries (36 out of 67) have extremely high rates (over 75 percent) of oil import dependency. These highly import dependent countries are also distributed throughout the nine categories. These countries could benefit considerably from the development of indigenous resources.

5. Most of these countries are very poor. Only 22 (those underlined) out of 67 have per capita annual incomes of over about $900. Most are already heavily dependent on biomass and could benefit directly from increased supplies as long as costs did not rise sharply. The major development of hydro resources could be constrained by low incomes unless electricity intensive industries geared for export can be attracted.

(tons oil equivalent per capita)

POTENTIAL HYDROELECTRIC

	Under 0.25		0.26-1.1		Over 1.1	Total
	Net energy exporters	Imports 26-75%	Imports 0-25%	Imports 75-100%	Imports 76-100%	
	Afghanistan*	Bangladesh*	Viet Nam*	Kenya*	Liberia*	
	Algeria	Ghana*		Niger*	Nepal*	
	Egypt*	Pakistan*	Imports 26-50%	Senegal*		
	Iran	Imports 76-100%	Chile	Sierra Leone*		
	Indonesia*	El Salvador*		Uganda*		
	Nigeria*	Guatemala		Upper Volta*		
	Syria	Korea, Rep. of				
	Imports 0-25%	Lesotho*				
	India*	Malawi*				
		Mali*				
		Morocco*				
		Philippines*				
		Sri Lanka*				
		Thailand*				
		Togo*				
		22		8	2	32
	Net exporters	Imports 76-100%	Net exporters	Imports 26-50%	Net exporters	
	Malaysia	Benin*	Cameroon*	Brazil	Zaire*	
	Mexico	Ethiopia*	Ecuador*	Zambia*	Imports 76-100%	
	Imports 0-25%	Somalia*	Mozambique*	Imports 76-100%	Madagascar*	
	Zimbabwe*		Peru	Chad*		
	Imports 26-75%		Venezuela	Costa Rica		
	Turkey		Imports 0-25%	Guinea*		
			Argentina	Honduras*		
			Burma*	Ivory Coast		
			Colombia	Mauritania*		
				Nicaragua		
				Panama		
				Sudan*		
				Tanzania*		
		7		20	2	29
			Net exporters	Imports 76-100%	Net exporters	
			Angola*	Paraguay	Bolivia	
				Uruguay	Congo, P.R.*	
					Imports 76-100*	
					Central African Republic*	
		0		3	3	6
Total		29		31	7	57

*Country has an actual or potential fuelwood problem. Based on World Bank, Energy in the Developing Countries (Washington, D.C., World Bank, 1980), p. 3.

Notes and sources: Hydroelectric potential is estimated as the annual energy potential per capita under conditions of average flow from installed and installable capacity, utilized twelve hours daily. A country is defined as having a low hydro potential if per capita potential is less than 0.25 toe and a high potential if per capita potential exceeds 1.1 toe. Adapted from the World Bank, Energy in the Developing Countries (Washington, D.C., World Bank, 1980), p. 96.

Theoretical biomass resource potential is an estimate of annual energy from the theoretical incremental growth of forests plus energy from animal wastes and crop residues. A country is defined as having a low biomass potential if per capita potential is less that 0.50 toe and a high potential if per capita potential is greater than 2.0 toe. Based on Dunkerley, et al. Energy Strategies for Developing Countries (Johns Hopkins University Press for Resources for the Future, Baltimore, 1981), pp. 173-177.

Net energy imports as a percent of total consumption of commercial fuels is 1980 data from the United Nations, 1980 Yearbook of World Energy Statistics (New York, United Nations, 1981).

Countries with 1980 per capita GNP of $900 and over are underlined.

Table 2. Country Energy Data

Region/ Country	Per capita GNP (1980 U.S.$)	Per capita reserves toe: potential Hydro-electric	Per capita reserves toe: Theo-retical Biomass	Per capita proven reserves toe: All Fossil Fuel	Per capita proven reserves toe: Of which Oil	Value of net oil imports as % total exports: pre-1980	Value of net oil imports as % total exports: 1980	Net energy imports as % of commercial energy consumption	Fuelwood Problem
Africa:									
Angola	470	0.50	2.61	27.21	23.06	-49.4	-49.4	-485.4	yes
Benin	310	0.20	0.82	-	-	53.3	106.7	100.0	yes
Burundi	200	n.a.	0.17	-	-	13.5	26.9	96.5	yes
Cameroon	670	1.05	1.02	6.12	2.48	-11.6	-11.6	- 55.9	yes
Central African Rep.	300	2.15	2.93	-	-	1.9	3.7	92.9	yes
Chad	120	0.30	1.39	-	-	30.8	61.5	100.0	yes
Congo, P.R.	900	2.22	4.06	80.15	38.53	-50.2	-50.2	-221.9	yes
Ethiopia	140	0.11	0.73	-	-	21.3	42.6	94.5	yes
Ghana	420	0.06	0.34	0.21	0.07	17.4	34.7	35.1	yes
Guinea	290	0.46	0.90	-	-	-	-	97.7	yes
Ivory Coast	1150	0.03	0.61	-	5.16	6.4	12.8	87.7	no
Kenya	420	0.34	0.29	-	-	18.0	36.0	96.8	yes
Lesotho	420	0.14	0.36	-	-	-	-	100.0	yes
Liberia	530	1.30	0.38	-	-	17.3	34.7	96.2	yes
Madagascar	350	2.84	0.88	-	-	14.8	29.5	79.6	yes
Malawi	230	0.01	0.37	-	-	25.0	50.0	91.0	yes
Mali	190	0.21	0.36	-	-	22.7	45.4	97.2	yes
Mauritania	440	0.49	0.80	-	-	-	-	100.0	yes
Mozambique	230	0.36	1.36	-	-	-	-	- 38.0	yes
Niger	330	0.71	0.48	-	-	10.9	21.7	100.0	yes
Nigeria	1010	0.01	0.19	44.44	31.17	-87.8	-87.8	-883.1	yes
Rwanda	200	n.a.	0.10	-	-	13.9	27.9	79.2	yes
Senegal	450	0.30	0.45	-	-	26.6	26.6	100.0	yes
Sierra Leone	280	0.36	0.12	-	-	15.8	31.7	100.0	yes
Somalia	n.a.	0.02	0.59	-	-	15.0	30.0	100.0	yes
South Africa	2300	n.a.	n.a.	-	-	0.5	0.9	1.3	no
Sudan	410	0.34	0.96	-	1.51	1.3	2.6	96.5	yes
Tanzania	280	0.45	0.87	-	-	24.4	48.8	93.5	yes
Togo	410	0.08	0.49	-	-	12.7	25.4	99.7	yes
Uganda	300	0.36	0.20	-	-	12.7	25.3	78.7	yes
Upper Volta	210	0.79	0.29	-	-	44.5	89.0	100.0	yes
Zaire	220	1.82	1.56	2.48	0.76	3.8	7.6	- 12.7	yes
Zambia	560	0.27	1.52	0.62	-	11.7	23.4	44.4	yes
Zimbabwe	630	0.25	1.22	-	-	23.9	47.9	12.0	yes
Asia:									
Afghanistan	n.a.	0.15	0.26	-	-	14.1	28.1	-176.0	yes
Bangladesh	130	0.01	0.23	7.16	0.7	32.4	64.8	60.1	yes
Bhutan	90	-	0.75	-	-	-	-	100.0	yes
Burma	170	0.85	0.53	0.21	0.14	2.6	5.3	4.4	yes
China	290	-	0.22	-	-	-	-	- 4.2	yes
Hong Kong	4240	-	-	-	-	5.6	5.6	100.0	no

India	240	0.04	0.28	36.67	0.34	31.9	63.7	24.5	yes
Indonesia	430	0.08	0.32	21.53	10.18	-50.7	-50.7	-175.0	yes
Kampuchea, Dem.	n.a.	-	-	-	-	-	-	100.0	yes
Korea, Dem. Rep.	n.a.	-	0.28	-	-	-	-	8.3	no
Korea, Rep.	1520	0.06	0.19	7.22	-	35.1	35.1	76.0	no
Lao PDR	n.a.	-	1.36	-	-	62.7	125.3	50.2	yes
Malaysia	1620	0.03	0.50	76.02	30.41	-5.5	-5.5	-49.5	no
Mongolia	n.a.	-	3.82	-	-	-	-	33.7	no
Nepal	140	2.17	0.46	-	-	-	-	87.5	yes
Pakistan	300	0.10	0.27	5.37	0.34	47.6	47.6	42.2	yes
Papua N. Guinea	780	2.26	-	-	-	13.0	26.0	94.8	no
Philippines	690	0.06	0.30	0.07	0.07	30.8	61.7	90.0	yes
Singapore	4430	-	-	-	-	10.6	10.6	100.0	no
Sri Lanka	270	0.03	0.14	-	-	31.9	31.9	93.5	yes
Thailand	670	0.06	0.39	4.40	-	30.1	60.1	94.8	yes
Viet Nam	n.a.	0.36	0.30	-	-	-	-	17.7	yes
Caribbean:									
Cuba	n.a.	-	1.08	-	-	12.1	24.3	97.1	no
Dominican Rep.	1160	-	0.47	-	-	51.4	51.4	99.8	no
Haiti	270	-	0.26	-	-	15.1	30.2	90.7	yes
Jamaica	1040	-	0.42	-	-	44.8	44.8	99.5	no
Trinidad & Tobago	4370	-	-	287.38	91.92	-63.1	-63.1	-128.3	no
Central America:									
Costa Rica	1730	0.76	0.72	-	-	19.9	39.8	80.8	no
El Salvador	660	0.08	0.27	-	-	8.4	16.7	84.0	yes
Guatemala	1080	0.07	0.44	0.34	0.34	11.3	22.6	92.9	no
Honduras	560	0.52	0.75	-	-	12.4	24.7	90.8	yes
Mexico	2090	0.12	0.50	108.57	69.01	-63.4	-63.4	-49.8	no
Nicaragua	740	0.53	1.07	-	-	40.9	40.9	94.3	no
Panama	1730	0.49	1.03	-	-	89.6	179.2	96.2	no
South America:									
Argentina	2390	0.67	1.76	36.12	13.14	3.1	6.2	9.7	no
Bolivia	570	1.25	2.40	33.51	4.06	-5.3	-5.3	-115.8	no
Brazil	2050	0.28	1.19	48.64	1.44	44.1	88.1	67.0	no
Chile	2150	0.54	0.36	27.73	5.44	13.3	26.6	51.7	no
Colombia	1180	0.72	1.22	21.19	3.99	7.1	14.3	8.5	no
Ecuador	1270	0.99	0.81	25.18	20.36	-45.3	-45.3	-137.4	yes
Paraguay	1300	0.75	2.25	-	-	41.9	41.9	83.9	no
Peru	930	0.28	1.47	12.73	5.64	16.1	32.1	-41.4	no
Uruguay	2810	0.32	2.16	-	-	35.8	71.6	91.3	no
Venezuela	3630	0.29	1.56	276.02	164.29	-92.0	-92.0	-265.4	no
Near & Middle East:									
Algeria	1970	0.10	0.14	265.29	69.28	-90.3	-90.3	-306.0	no
Egypt	530	0.03	0.16	14.65	11.21	-40.9	-40.9	-26.4	yes

Iran	n.a.	0.10	0.35	500.08	203.94	-96.6	-96.6	-163.6	no
Iraq	3020	-	0.28	371.47	322.84	-98.6	-98.6	-1576.6	no
Israel	4500	-	-	-	-	29.4	58.7	98.2	no
Jordan	1420	-	0.05	-	-	61.0	122.0	100.0	no
Lebanon	n.a.	-	0.07	-	-	-	-	96.6	no
Morocco	900	0.02	0.09	-	-	30.9	61.7	86.9	yes
Syrian Arab Rep.	1340	0.05	0.23	40.18	35.71	-23.3	-23.3	-22.1	no
Tunisia	1310	-	0.27	18.85	12.35	-22.5	-22.5	-81.2	no
Yemen Arab Rep.	430	-	0.22	-	-	249.4	498.7	100.0	yes
Yemen PDR	420	-	0.39	-	-	-	-	100.0	yes
Europe:									
Albania	n.a.	-	-	-	-	-	-	3.8	no
Greece	4380	-	-	40.46	2.13	31.6	31.6	81.0	no
Portugal	2370	0.23	-	-	-	39.8	39.8	91.5	no
Romania	2340	0.13	-	-	-	-	-	18.2	no
Turkey	1470	0.13	0.67	13.07	0.41	73.5	147.0	57.4	no
Yugoslavia	2520	0.28	-	264.68	1.68	31.9	31.9	40.9	no

Note: n.a. = Data not available, "-" indicates no reserves or data not available.

Source: Per capita Gross National Product (GNP) from World Bank, World Development Report 1982, (Washington, D.C., World Bank, 1982), pp. 110-111. In 1980 U.S. dollars.

Per capita hydroelectric potential, fossil fuel and petroleum reserves adapted from World Bank, Energy in the Developing Countries (Washington, D.C., World Bank, August 1980), pp. 80-86. Hydroeletric potential is estimated as the annual energy potential per capita under conditions of average flow from installed and installable capacity, utilized twelve hours per day.

Theoretical biomass resource potential is an estimate of annual energy from the theoretical incremental growth of forests plus energy from animal wastes and crop residues. The lower end of the theoretical range was choosen as a conservative estimate since these are theoretical resources. Based on Dunkerley, et. al., Energy Strategies for Developing Nations (Johns Hopkins University Press for Resources for the Future, Baltimore, 1981), pp. 173-177.

Trade data are for the latest year available for the value of net imports of petroleum and petroleum products and for total merchandise exports (in thousand U.S. dollars) from the United Nations, 1980 Yearbook of International Trade Statistics, vol. 1 (New York, United Nations, 1981). The 1980 percentage is estimated by approximately doubling the pre-1980 figure in order to account for the large increase in oil prices in 1979-80, unless the data available are from 1980 or the country is a net oil exporter; in both cases, the percentage is not adjusted. Net energy imports as a percent of commercial energy consumption is 1980 data from the United Nations, 1980 Yearbook of World Energy Statistics (New York, United Nations, 1981). Consumption includes stocks, bunkers and unaccounted.

Fuelwood status assessment is based on World Bank, Energy in the Developing Countries (Washington, D.C., World Bank, August 1980), p. 5. A country is considered to have a fuelwood problem "if estimated annual consumption of fuelwood could not be sustained through the year 2000, without damage to the ecology, at a level of 0.75 m3 per capita where income per head (in 1978) was below $300, falling linearly to 0.5 m3 at $600 and zero at $900. Many countries not included in this group have or will have fuelwod problems in local areas."

Table 3. Frequency Distribution for Per Capita Output based on Theoretical Biomass Resources

(code is output in toe)

CODE	FREQ	ADJ PCT	CUM PCT	CODE	FREQ	ADJ PCT	CUM PCT	CODE	FREQ	ADJ PCT	CUM PCT
0.05	1	1	1	0.32	1	1	35	0.81	1	1	68
0.07	1	1	2	0.34	1	1	36	0.82	1	1	69
0.09	1	1	4	0.35	1	1	37	0.87	1	1	70
0.10	1	1	5	0.36	1	1	38	0.88	1	1	71
0.10	1	1	6	0.36	1	1	39	0.90	1	1	73
0.12	1	1	7	0.36	1	1	40	0.96	1	1	74
0.14	1	1	8	0.37	1	1	42	1.02	1	1	75
0.14	1	1	10	0.38	1	1	43	1.03	1	1	76
0.16	1	1	11	0.39	1	1	44	1.07	1	1	77
0.17	1	1	12	0.39	1	1	45	1.08	1	1	79
0.19	1	1	13	0.42	1	1	46	1.19	1	1	80
0.19	1	1	14	0.44	1	1	48	1.22	1	1	81
0.20	1	1	15	0.45	1	1	49	1.22	1	1	82
0.22	1	1	17	0.46	1	1	50	1.36	1	1	83
0.22	1	1	18	0.47	1	1	51	1.36	1	1	85
0.23	1	1	19	0.48	1	1	52	1.39	1	1	86
0.23	1	1	20	0.49	1	1	54	1.47	1	1	87
0.26	1	1	21	0.50	1	1	55	1.52	1	1	88
0.26	1	1	23	0.50	1	1	56	1.56	1	1	89
0.27	1	1	24	0.53	1	1	57	1.56	1	1	90
0.27	1	1	25	0.59	1	1	58	1.76	1	1	92
0.27	1	1	26	0.61	1	1	60	2.16	1	1	93
0.28	1	1	27	0.67	1	1	61	2.25	1	1	94
0.28	1	1	29	0.72	1	1	62	2.40	1	1	95
0.28	1	1	30	0.73	1	1	63	2.61	1	1	96
0.29	1	1	31	0.75	1	1	64	2.93	1	1	98
0.29	1	1	32	0.75	1	1	65	3.82	1	1	99
0.30	1	1	33	0.80	1	1	67	4.06	1	1	100

Table 4. Frequency Distribution for Per Capita Output based on Potential Hydro Resources

(code is output in toe)

CODE	FREQ	ADJ PCT	CUM PCT	CODE	FREQ	ADJ PCT	CUM PCT	CODE	FREQ	ADJ PCT	CUM PCT
0.01	3	4	4	0.21	1	1	42	0.54	1	1	76
0.02	2	3	7	0.23	1	1	44	0.67	1	1	77
0.03	1	1	8	0.25	1	1	45	0.71	1	1	79
0.03	3	4	13	0.27	1	1	46	0.72	1	1	80
0.04	1	1	14	0.28	2	3	49	0.76	1	1	82
0.05	1	1	15	0.28	1	1	51	0.76	1	1	83
0.06	3	4	20	0.29	1	1	52	0.79	1	1	85
0.06	1	1	21	0.30	1	1	54	0.86	1	1	86
0.07	1	1	23	0.30	1	1	55	0.99	1	1	87
0.08	2	3	25	0.32	1	1	56	1.05	1	1	89
0.08	1	1	27	0.34	3	4	61	1.25	1	1	90
0.10	2	3	30	0.36	1	1	62	1.30	1	1	92
0.10	1	1	31	0.36	2	3	65	1.82	1	1	93
0.11	1	1	32	0.45	1	1	66	2.15	1	1	94
0.12	1	1	34	0.46	1	1	68	2.17	1	1	96
0.13	2	3	37	0.49	2	3	70	2.22	1	1	97
0.14	1	1	38	0.50	1	1	72	2.26	1	1	99
0.15	1	1	39	0.52	1	1	73	2.84	1	1	100
0.20	1	1	41	0.53	1	1	75