REGIONAL WOOD ENERGY DEVELOPMENT PROGRAMME IN ASIA
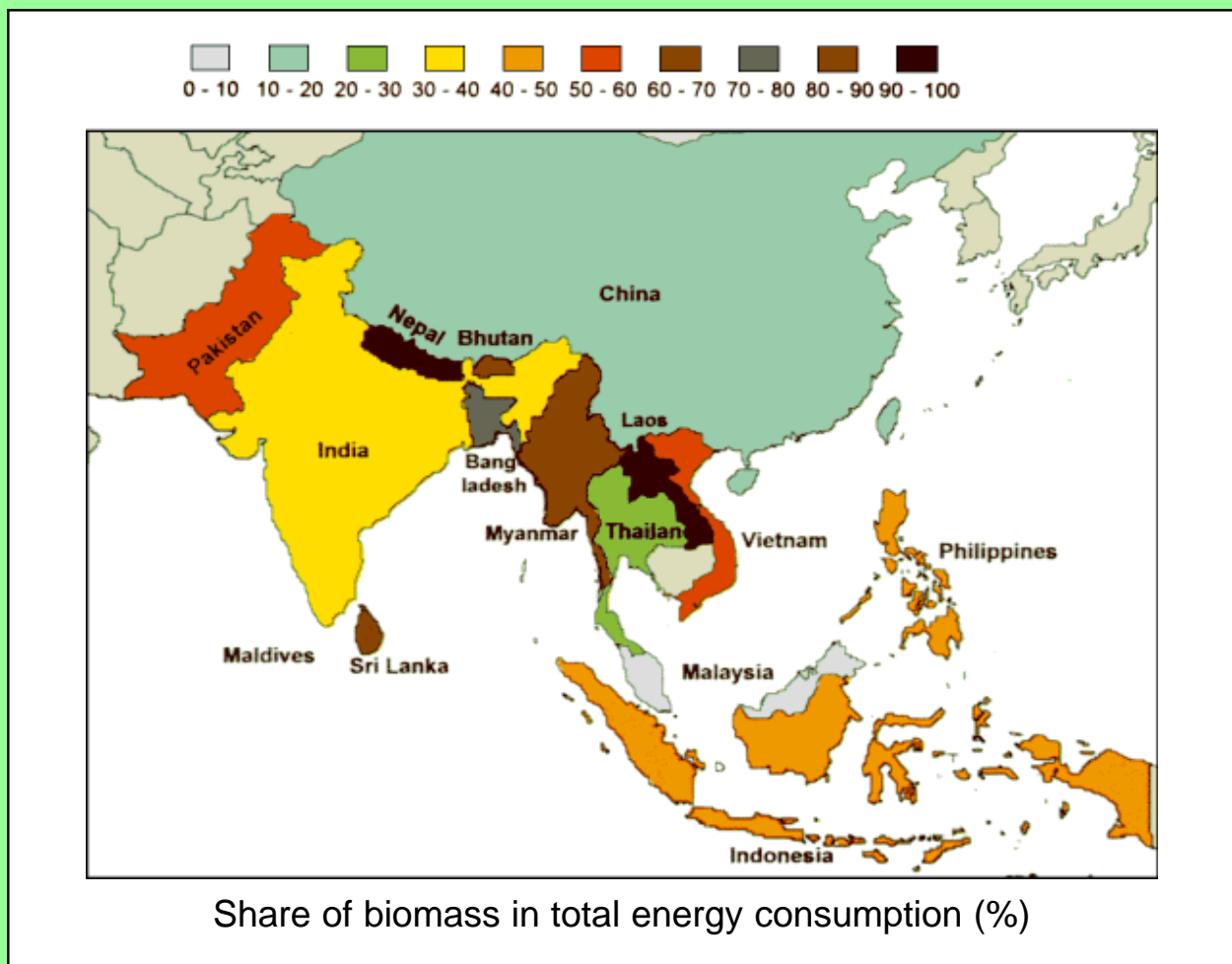## GCP/RAS/154/NET

REVIEW OF WOOD ENERGY DATA IN RWEDP MEMBER COUNTRIES

Share of biomass in total energy consumption (%)

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
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FOREWORD

Wood and other biomass constitute major sources of fuel in all RWEDP member countries. Further wood energy development needs to be based on appropriate strategies, policies and planning, which, of course, require adequate data. However, data on the supply and utilization of wood energy are still patchy and even sometimes conflicting. RWEDP, jointly with its member countries, is in the process of collecting, assessing and compiling relevant data. As yet, no comprehensive review has been published.

The review presented in this field document is based upon secondary data available from sources at Thailand-based documentation centers, e.g. at FAO-RWEDP, other UN offices and AIT. It makes clear that significant differences exist between countries with respect to data availability. Hence, the document allows for analyzing data gaps and preparing for further strengthening of data bases, e.g. by identifying additional data sources in member countries and eventually by cost-effective primary data collection efforts.

The structure of the review has followed the RWEDP Guidelines for Wood/Biomass Energy Data Base Development, which lays out a framework for a wood energy data base, and which is compatible with FAO and other UN formats. The review allows for a quick insight into country situations, but the available data do not (yet) allow regional statistical comparisons. Aggregation is hampered by the deployment of different definitions and units in different countries. Furthermore, inconsistencies still apply between data from different sources. (It should be noted that similar inconsistencies can be observed in data sources on conventional fuels and forest resources!)

RWEDP aims to assist in institutionalizing wood energy data collection, assessment and analysis in member countries by capacity building and other measures. Recently, a follow-up study on 'Wood Energy Today for Tomorrow' was commissioned jointly with FAO Headquarters, and this study is to be followed by further studies and analyses. Facilitating and eventually instituting routines for continuously updating national and regional overviews of relevant data in computerized systems is the ultimate aim of our efforts as we believe this will best support wood energy policy making and planning in the region.

The report starts with an overview of some regional data and then presents data for individual countries. Cambodia has been included, as it may soon join RWEDP. Furthermore, a chapter on measurements and units is included and a list of references. The report was compiled by Mr. Jossy Thomas and was validated by Mr. Jaap Koppejan, Ms. Feli Ariola, Ms. Ruby Buen and Joost Siteur. Mr. Conrado Heruela and other colleagues at RWEDP acted as advisers. Some comments from the Wood Energy Today study conducted by the Energy Planning Central Consultant Team of AIT were incorporated. Further comments and suggestions on this document from readers are most welcome.

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1. INTRODUCTION: REGIONAL OVERVIEW

In this report, national overviews are presented that show the situation of wood energy consumption in all RWEDP member countries. The tables follow the data framework presented in the document 'Guidelines for a Wood Energy Database', and contain country level information on geography, demography, land use patterns, economy and energy, with specific reference to wood energy. In this introduction an attempt is made to bring together information from these different countries to highlight some common trends and differences.

Table 1.1. shows the differences in consumption of traditional energy, based on annually published WRI data (WRI, 1994). Growth rates for biomass energy consumption are calculated for the 1981-1991 period, both for total consumption as well as per capita and per unit of GDP. It shows for example that although the use of traditional energy per capita in Bangladesh is decreasing and below the regional average, it is still increasing in absolute terms, probably because of a rapid population growth. This trend is true for many other countries as well. In Bangladesh, the economy relies more on traditional energy sources than many other countries.

Table 1.1. Traditional energy consumption in the RWEDP region, 1991

| | Population | GDP/cap | Traditional Energy Consumption | | | | | |
| | | | Total | | Per Capita | | Per unit of GDP | |
	(million)	(const. US$)	(PJ)	av. ann. growth	(GJ/cap)	av. ann. growth	(GJ/$)	av. ann. growth
Bangladesh	116.4	176	276.6	1.3%	2.4	-1.2%	13.5	-2.7%
Bhutan	1.6	200	11.7	4.8%	7.4	2.6%	37.2	-1.6%
Cambodia	8.6	-	5.4	2.7%	0.6	0.0%	NA	NA
China	1170.7	337	2,017.8	2.7%	1.7	1.2%	5.1	-5.9%
India	862.7	370	2,823.7	2.7%	3.3	0.6%	8.8	-2.4%
Indonesia	187.7	523	1,464.8	2.2%	7.8	0.2%	14.9	-3.1%
Lao PDR	4.3	310	38.5	2.8%	8.9	-0.1%	28.7	NA
Malaysia	18.3	2,449	90.2	2.7%	4.9	0.0%	2.0	-3.3%
Maldives	0.2	-	-	-	-	-	-	-
Myanmar	42.7	243	192.8	2.1%	4.5	0.0%	18.5	1.0%
Nepal	20.1	166	205.7	6.2%	10.2	3.3%	61.6	1.6%
Pakistan	121.5	341	296.2	4.4%	2.4	1.1%	7.1	1.5%
Philippines	63.8	596	381.8	2.2%	6.0	-0.3%	10.0	1.0%
Sri Lanka	17.4	455	89.4	2.5%	5.1	1.0%	11.3	1.6%
Thailand	55.4	1,334	526.4	0.8%	9.5	-0.6%	7.1	6.6%
Vietnam	68.1	721	250.8	2.4%	3.7	0.3%	5.1	NA
Total	2759.4	400	8,671.9	2.5%	3.1	0.6%	7.9	-4.2%

Source: World Resources Institute, 1994

Malaysia, which has the highest per capita income, still uses more traditional energy per capita than the regional average, but this figure has remained constant since wood and other biomass energy sources are readily available in Malaysia. Moreover, the economy does not rely on it, as the share of wood and biomass in total energy consumption is only 7% (see Table 1.2.).

The dependency of different RWEDP member countries on wood and other biomass energy sources is indicated in Table 1.2. The data is compiled from different sources. Official energy

balances, published by government agencies, were available from only six countries. All other data were derived from international agencies and NGO's. The different methods used for obtaining the data and the different units and categories adopted cause large differences in data and make it hard to aggregate data at the regional level. Although in all countries the share of biomass is stable or declining, on an absolute scale it is increasing in every country.

While the dependency of households on biomass energy is very high for countries such as Bangladesh, Nepal and Sri Lanka, many households in China and Malaysia have switched to other fuels already.

Table 1.2. Shares of wood and biomass in the total energy consumption

Country	Year	Share of biomass	Share of wood	Biomass share in domestic energy
Bangladesh[2]	1992	73%	13%	89%
Bhutan[3]	1991	82%		
Cambodia[2]	1994	86%	83%	98%
China[4]	1992	10%		25%
India[4]	1992	33%		78%
Indonesia[5]	1992	39%	31%	73%[1]
Laos[3]	1991	88%		
Malaysia[5]	1992	7%	2%	15%[1]
Maldives[6]	1994		23%	84%
Myanmar[3]	1991	74%		
Nepal[2]	1992-1993	92%	68%	97%
Pakistan[2]	1993-1994	47%	27%	83%
Philippines[5]	1992	44%	26%	66%[1]
Sri Lanka[2]	1990	77%		93%
Thailand[2]	1994	26%	9%	65%[1]
Vietnam[3]	1991	50%		

1   This figure also includes the commercial sector
2   from the national energy balance
3   Source: World Resource Institute, 1994
4   Source: United Nations Energy Balances, 1992
5   Source: ASEAN EC Energy Management Training and Research Centre, 1994
6   Source: United Nations Mission Report 1993

Information from various sources on the use of woodfuels, either directly as fuelwood or after conversion into charcoal, is shown in Table 1.3. The lion's share of all woodfuels used in the RWEDP region is consumed by households in the form of fuelwood. Domestic use of charcoal is generally reported to be low in comparison to fuelwood.

Table 1.3. Fuelwood and charcoal consumption in the domestic and industrial sectors (PJ)

Country	Fuelwood			Charcoal			Fuelwood and Charcoal	Year
	Domestic	Industrial	Total	Domestic	Industrial	Total		
Bangladesh[1]	96	19	115	0	0	0	115	1989/90
Bhutan[2]	12	1	14	0	0.4	0.4	14	1988/89
Cambodia	-	-	-	-	-	-	-	-
China[3]	3,495	0	3,495	0	0	0	3,495	1990
India[4]	3,165	240	3,405	0	0	0	3,405	1991
Indonesia[5]	869	0	869	0	0	0	869	1992
Laos[6]	33	0	33	0	0	0	33	1990
Malaysia[7]	12	0	12	6	0	6	18	1992
Maldives[8]	1	0	1	0	0	0	1	1987
Myanmar[9]	343	0	343	25	0	25	368	1990
Nepal[10]	169	6	176	0	0	0	176	1994/95
Pakistan[11]	494	0	494	0	0	0	494	1993/94
Philippines[12]	232	0	232	57	0	57	289	1992
Sri Lanka[13]	136	0	163	0	0	0.5	164	1992
Thailand[14]	162	0	162	185	0	185	277	1994
Vietnam[15]	396	0	427	15	0.1	16	443	1990

1   *Rural Energy and Environment Planning for Sustainable Rural Development in Bangladesh. Ahsan Habib, 1994*
2   *Wood Energy Sectoral Analysis. FAO-RWEDP, Field Document 32*
3   *ESCAP - Executive Seminar and Study Tour, 1991*
4   *Biomass, Energy and Environment. N.H. Ravindranath and D.O. Hall 1995 (Table 2.2 Low Est.)*
5   *ASEAN Energy Review. Vol. 3, AEEMTRC, 1994*
6   *Sectoral Energy Demand in Laos, REDP, 1989*
        7 ASEAN Energy Review. Vol. 3, AEEMTRC, 1994
8   *Sectoral Energy Demand in the Maldives, REDP, 1989*
9   *Myanmar Energy Sector Investment and Policy Review Study. WB 1991 (Annex 1.2b)*
10   *Energy Synopsis Report. Water and Energy Commission, April, 1996*
11   *Asian Energy News, November 1995,*
12   *ASEAN Energy Review Vol. 3, AEEMTRC, 1994*
13   *Sri Lanka Energy Balance. Ministry of Power and Energy, September 1995*
14   *Thailand Energy Situation, 1994. Department of Energy Development and Promotion, 1995*
15   *Vietnam: Rural and Household Energy Issues and Options. WB-ESMAP, 1994*

Table 1.4. gives more information on the wood resources available. Bangladesh has a relatively low amount of natural forest cover (5.9%) but an additional 3.6% of the country is defined as other wooded land. Other countries such as Bhutan, Indonesia, Laos and Malaysia still have relatively large forest areas left. It is also clear that out of the total roundwood production in the RWEDP member countries, the major share ends up as woodfuel, even though in most cases trees are felled for timber production, land clearing for agriculture or other purposes.

Table 1.4. *Land area, forest and other wooded land, roundwood production and share of woodfuel in total roundwood production*

RWEDP Member Country	Total Land Area (million ha)	Total Forest[1] and Other Wooded Land[2] (million ha)	%	Natural Forest Area in 1990 (million ha)	%	Plantation[3] Area in 1990 (million ha)	%	Other Wooded Land in 1990 (million ha)	%	Total Roundwood Production in 1994 (million cum)	Total Woodfuel Production in 1994 (million cum)	Share of Woodfuel in Total Roundwood Production (%)
Bangladesh	13.017	1.472	11.3	0.769	5.9	0.335	2.6	0.468	3.6	31.346	30.620	97.7
Bhutan	4.700	3.169	67.4	2.809	59.8	0.005	0.1	0.355	7.6	1.398	1.334	95.4
Cambodia												
China	932.641	162.029	17.4	101.968	10.9	31.831	3.4	28.230	3.0	305.961	204.059	66.7
India	297.319	82.648	27.8	51.729	17.4	18.900	6.4	17.689	5.9	293.979	206.187	70.1
Indonesia	181.157	145.108	80.1	109.550	60.5	8.750	4.8	29.434	16.2	187.089	148.92	79.6
Laos	23.080	21.436	92.9	13.170	57.1	0.006	0.0	8.259	35.8	5.094	4.382	86.0
Malaysia	32.855	22.248	67.7	17.580	53.5	0.116	0.4	4.584	14.0	46.037	9.602	20.9
Maldives	0.001	NA	NA	0.001		NA	NA	NA	NA	NA	NA	NA
Myanmar	65.755	49.774	75.7	28.860	43.9	0.335	0.5	20.683	31.5	22.484	20.040	89.1
Nepal	13.680	5.751	42.0	5.023	36.7	0.080	0.6	0.672	4.9	20.312	19.692	96.9
Pakistan	77.088	3.128	4.1	1.855	2.4	0.240	0.3	1.105	1.4	29.873	27.419	91.8
Philippines	29.817	13.64	45.7	7.830	26.3	0.290	1.0	5.606	18.8	38.990	35.790	91.8
Sri Lanka	6.463	3.998	61.9	1.746	27.0	0.198	3.1	2.113	32.7	9.493	8.82	92.9
Thailand	51.089	14.968	29.3	12.730	24.9	0.756	1.5	1.704	3.3	38.914	36.130	92.8
Vietnam	32.549	23.499	72.2	8.310	25.5	2.100	6.5	13.717	42.1	34.209	29.810	87.1
TOTAL	1761.211	552.868	31.4	363.93	20.7	63.942	3.6	134.619	7.6	1065.179	782.796	73.5

Source: Land and Forest and Other Wooded Land Area (for all countries except Maldives) taken from World Resources 1996-97: The Urban Environment (WRI 1996), Data for Maldives from RAP Publication 1995/22: Selected Indicators of Food and Agriculture Development in Asia-Pacific Region, 1984-94 (FAO/Bangkok, 1995); Natural Forest and Plantation Area for all countries (except China and Maldives) from FAO Forestry Paper 112: Forest Resources Assessment 1990: Tropical Countries (FAO/Rome, 1993); Total Roundwood and Woodfuel Production from FAO Yearbook: Forest Products 1983-1994 (FAO/Rome, 1994).

Note:
1. Forest Area includes the ecosystems with a minimum of 10 percent crown cover of trees and/or bamboo.
2. Other Wooded Land includes shrubs and short fallow.
3. Plantation includes both forest and agricultural (industrial and non-industrial) tree plantations.

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2. BANGLADESH

2.1. The Country

Bangladesh consists of low, flat and fertile land except for the hilly regions of the north-east and the south-east. The country is bounded by India on the west, north, and the north east, Myanmar on the south east and the Bay of Bengal on the south.

2.2. Population and Land Use

Based on the national census of 1991, the population of Bangladesh is 108.8 million. The rural population of the country is about 84.8% and the remaining 15.2% live in the urban areas. The population growth rate is 2.1 per annum and the population is expected to reach 140 million by the year 2000.

Table 2.1. Population, land use data and fuelwood production, 1987-93

	Unit	1987	1988	1989	1990	1991	1992	1993
Total population	`000	102,277	104,123	106,052	108,118	110,341	112,709	115,203
Agricultural population	`000	72,113	72,736	73,385	74,098	74,887	75,739	76,633
Total land	`000ha	13,017	13,017	13,017	13,017	13,017	13,017	13,017
Arable + permanent crop	`000ha	9,248	9,463	9,482	9,786	9,721	9,694	9,694
Irrigated land	`000ha	2,199	2,347	2,737	2,936	3,027	3,100	3,100
Forest + woodland	`000ha	1,987	1,903	1,903	1,903	1,899	1,890	1,900
Fuelwood production*	`000m^3	27,533	28,191	28,863	29,557	30,275	31,014	31,774

Source: Country Tables, FAO, Rome (1995)   ** includes fuelwood converted to charcoal.*

Out of the total land area of 13.0 Mha about 14.6% is under forest cover. 74.5% of the land area is under permanent crop lands and 23.8% is irrigated. Studies using the latest remote sensing techniques have revealed the present land cover types and their variations over the years (table 2.2). As per these data, the evergreen forest cover in Bangladesh reduced from 7.4% to 3.2% between 1985/86 and 1992/93. Degraded forests due to shifting cultivation extended from 3.9% to 6.1% of the total land area during this period.

Table 2.2 Land cover type and extent in Bangladesh

Land cover category	1985-86		1992-93	
	km^2	%	km^2	%
Evergreen forest	10,369	7.4	4,483	3.2
Degraded forest (Shifting cultivation)	5,418	3.9	8,517	6.1
Mangrove forest	4,668	3.4	4,513	3.2
Marshes	593	0.4	1,124	0.8
Grass land	1,874	1.3	1,706	1.2
Agriculture	94,323	67.6	92,331	66.2
Boro rice	4,748	3.4	5,927	4.3
Barren lands	13,050	9.4	14,325	10.3
Water bodies	4,087	2.9	5,673	4.1
No data available	365	0.3	894	0.6
Total	139,495	100.0	139,493	100.0

Source: Land Cover Assessment and Monitoring - Bangladesh, Vol. 2-A, UNEP, Bangkok, (1995)

2.3. Economy

The economy of Bangladesh is predominantly agricultural and relies heavily on natural resources. Although the agricultural production has increased due to increased irrigation facilities and use of chemical fertilizers, the contribution of this sector towards the GDP reduced from 46.6% in 1982 to 34.5% in 1992.

Table 2.3. Major economic indicators of Bangladesh, 1985-1993

Economic indicators	1985	1986	1987	1988	1989	1990	1991	1992	1993
GDP (1987 US$ million)	16,200	16,907	17,601	18,100	18,546	19,779	20,447	21,299	22,238
GDP (curr. US$ million)	15,651	15,600	17,601	19,111	20,521	22,397	23,394	23,760	23,977
GDP growth (%/y)	3.9	4.4	4.1	2.8	2.5	6.6	3.4	4.2	4.4
GNI/capita (1987 US$)	170	170	170	170	170	180	180	190	190
GNI growth (%/y)	5.4	2.3	4.6	3.4	1.6	6.7	3.4	4.2	4.5
GNP/capita (curr. US$)	150	160	180	190	200	210	220	220	220

Source: World Tables, World Bank, (1995)

2.4. Energy Situation

Traditional energy consisting of fuelwood, agricultural residues and dung dominate the primary energy production and supply in Bangladesh. The amount of traditional energy produced in 1982, (about 17,142 ktoe) has grown to 20,368 ktoe in 1992 but with a lower growth rate of 1.7% compared to conventional energy which had a growth rate of 10.4%.

Table 2.4. Structure of traditional energy production (ktoe)

Year	Fossil fuel	Hydro power	Conventional	Woodfuel	Agr. residues	Dung	Traditional
81-82	1,577	154	1,731	1,886	13,439	1,817	17,141
82-83	1,630	183	1,813	1,901	13,724	1,814	17,439
83-84	1,856	255	2,111	1,916	13,999	1,828	17,743
84-85	2,086	206	2,292	1,932	14,243	1,859	18,052
85-86	2,353	126	2,479	1,892	14,638	1,837	18,366
86-87	2,706	139	2,845	1,887	14,929	1,850	18,685
87-88	3,348	187	3,535	1,997	15,056	1,977	19,010
88-89	3,551	255	3,806	2,553	14,777	1,992	19,341
89-90	3,592	225	3,817	2,538	15,309	1,810	19,678
90-91	3,741	222	3,963	2,923	15,235	1,882	20,020
91-92	3,927	207	4,134	3,096	15,378	1,894	20,368

Source: Zaki, Rabiul Hossain, "Analysis of Energy Demand and Household Energy Demand Forecasting: A Case of Bangladesh", Thesis, AIT, Bangkok (1994)
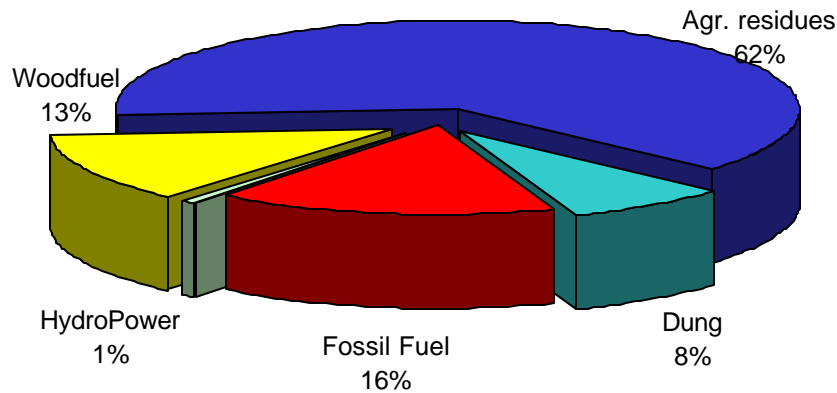
Figure 2.1   Shares of traditional & conventional energy sources (AIT, 1994)

Traditional energy constituted about 83% of the total primary energy production in 1992 whereas this share was 91% in 1982. The reason for this decrease is the reduced availability of traditional fuels and increased production of conventional fuels. Agricultural residues contributed 75.5% to the total traditional energy production in 1992 which is a slight decrease from 78% in 1982. It is interesting to note that the share of fuelwood increased from 11% in 1982 to 15% in 1992. The contribution of animal dung in the total primary energy production is 9%.

Conventional energy production has grown at the rate of 10.4% per annum which has resulted in the increase of the conventional energy share from 9% in 1982 to 17% in 1992. The reason for this high growth rate and increase in share is the massive infusion of indigenous natural gas. The share of natural gas increased from 9% in 1982 to 19% in 1992. Within the conventional energy segment, its share increased from 91% in 1982 to 94% in 1992.

Table 2.5. Nature of primary and final energy (%)

Year	Primary energy		Final energy	
	Traditional	Conventional	Traditional	Conventional
81-82	83.7	16.3	86.6	13.4
82-83	84.6	15.4	87.6	12.4
83-84	83.6	16.4	86.9	13.1
84-85	82.9	17.1	86.5	13.5
85-86	82.6	17.4	85.9	14.1
86-87	81.0	19.1	85.0	15.1
87-88	77.4	22.6	82.3	17.7
88-89	76.3	23.7	81.2	18.8
89-90	76.7	23.3	81.0	19.0
90-91	76.5	23.5	82.6	17.4
91-92	75.9	24.1	82.0	18.1

Source: Zaki, Rabiul Hossain, "Analysis of Energy Demand and Household Energy Demand Forecasting: A Case of Bangladesh", Thesis, AIT (1994)

2.5. Final Energy Consumption Pattern

Final energy consumption in Bangladesh is dominated by traditional energy, equivalent to 17,141 ktoe in 1982 and 20,401 ktoe in 1992. But its share in the overall energy consumption decreased from 86.6% in 1982 to 81.9% in 1992. The major constituent of traditional energy is agricultural residues with a share of 61.5% in 1992. Introduction of high yielding varieties of crops with high crop to residue ratios has restricted its growth. The share of woodfuel increased from 9.5% in 1982 to 12.4% in 1992 with a growth rate of around 6% per annum. Animal waste or dung constitutes 7.6% of the total energy consumption. Its share decreased from 9.2% in 1992.

The amount of conventional energy consumed in the year 1992 was around 4,527 ktoe and its share in the final energy consumption accounted for 18.1%, this was 13.4% in the year 1982.

Table 2.6. Urban household energy consumption by fuel

Year	Kerosene (ktoe)	LPG (ktoe)	Nat. gas (ktoe)	Electricity (ktoe)	Fuelwood (ktoe)	Total (ktoe)	Share of conventional	Share of traditional
81-82	168	0	118	29	676	991	32%	68%
82-83	185	5	142	36	721	1,090	34%	66%
83-84	204	7	153	48	794	1,206	34%	66%
84-85	236	9	168	54	832	1,298	36%	64%
85-86	240	10	179	61	840	1,330	37%	63%
86-87	274	9	180	66	870	1,399	38%	62%
87-88	293	10	201	74	889	1,467	39%	61%
88-89	236	10	244	89	1,144	1,723	34%	66%
89-90	332	10	256	102	1,275	1,975	35%	65%
90-91	275	10	266	105	1,289	1,945	34%	66%
91-92	235	9	301	103	1,431	2,078	31%	69%

Source: Zaki, Rabiul Hossain, "Analysis of Energy Demand and Household Energy Demand Forecasting: A Case of Bangladesh", Thesis, AIT, Bangkok (1994)

The residential sector consumes the maximum amount of energy in Bangladesh, about 12,831 ktoe of final energy in 1992, out of which traditional energy accounts for 12,052 ktoe or 93.9%. Conventional energy is consumed mainly in urban households.

The industrial sector consumed 43.5% of the final energy and holds the second position. The commercial, agriculture and transport sectors consumed 1%, 1% and 3% of final energy in the year 1992, respectively.

Table 2.7. Rural household energy consumption by fuel (ktoe)

Year	Agr. res	Dung	Fuelwood	Total trad	Total comm	Total	Share of traditional (%)
81-82	6,890	1,820	745	9,455	166	9,621	98.3%
82-83	7,140	1,822	748	9,710	124	9,834	98.7%
83-84	7,306	1,855	773	9,934	128	10,062	98.7%
84-85	7,334	1,862	742	9,938	134	10,072	98.7%
85-86	7,713	1,868	735	10,316	129	10,445	98.8%
86-87	7,746	1,853	722	10,321	123	10,444	98.8%
87-88	7,350	1,870	693	9,913	133	10,046	98.7%
88-89	6,897	1,877	805	9,579	144	9,723	98.5%
89-90	8,132	1,883	829	10,844	148	10,992	98.7%
90-91	7,796	1,884	831	10,511	130	10,641	98.8%
91-92	7,869	1,891	862	10,622	131	10,753	98.8%

Source: Zaki, Rabiul Hossain, "Analysis of Energy Demand and Household Energy Demand Forecasting: A Case of Bangladesh", Thesis, AIT, Bangkok (1994)
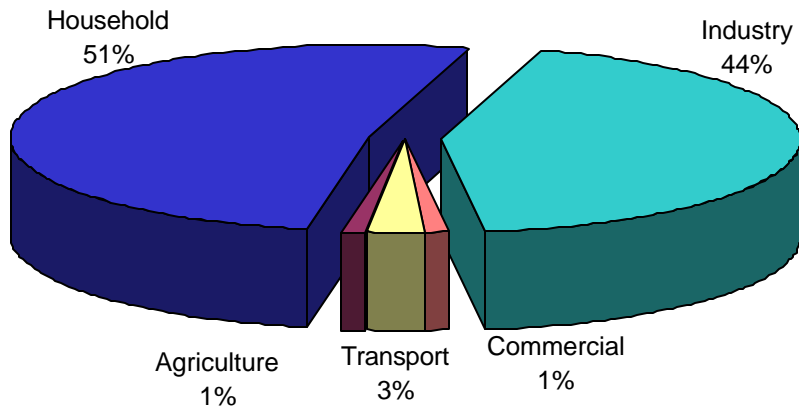
Figure 2.2 Final energy consumption by sector, 1992 (Zaki, 1994)

The sectoral energy consumption pattern for a period of 1981/82 to 91/92 is given in Table 2.8. The share of the household sector is on a gradual decline and the share of the transport sector has increased correspondingly.

Table 2.8. Sectoral share of total energy consumption

Year	Household (%)	Commercial (%)	Industry (%)	Transport (%)	Agriculture (%)	Total (%)
81-82	54.0	0.7	43.0	2.0	0.2	100.0
82-83	54.7	0.7	42.3	2.1	0.3	100.0
83-84	54.6	0.7	42.1	1.8	0.9	100.0
84-85	54.8	0.8	41.5	2.0	1.0	100.0
85-86	54.7	0.8	41.4	2.1	1.0	100.0
86-87	53.7	0.9	42.1	2.4	1.0	100.0
87-88	52.7	0.9	42.8	2.4	1.2	100.0
88-89	51.7	1.1	43.2	2.7	1.2	100.0
89-90	52.0	1.0	43.4	2.8	0.9	100.0
90-91	52.1	1.0	43.3	2.7	0.9	100.0
91-92	51.8	1.0	43.5	2.7	1.0	100.0

Source: Zaki, Rabiul Hossain, "Analysis of Energy Demand and Household Energy Demand Forecasting: A Case of Bangladesh", Thesis, AIT, Bangkok (1994)

The household sector consumes the major share of energy in Bangladesh, followed by the industry sector. Approximately 94% of the fuels used by households are traditional and the main end use is cooking.

Table 2.9. Total energy consumption in the household sector (ktoe)

Year	Conventional					Traditional				Total	Relative share (%)	
	Kerosene	LPG	Nat. gas	Electr.	Total	Fuelwood	Agr. res	Dung	Total		Conventional	Traditional
81-82	333	0	118	29	480	1,421	6,890	1,820	10,131	10,611	4.5%	95.5%
82-83	307	5	142	38	492	1,469	7,027	1,822	10,318	10,810	4.6%	95.4%
83-84	330	7	153	51	541	1,567	7,306	1,855	10,728	11,269	4.8%	95.2%
84-85	366	9	168	58	601	1,574	7,334	1,862	10,770	11,371	5.3%	94.7%
85-86	365	10	179	66	620	1,575	7,713	1,868	11,156	11,776	5.3%	94.7%
86-87	375	9	180	72	636	1,591	7,746	1,853	11,190	11,826	5.4%	94.6%
87-88	418	10	201	82	711	1,583	7,350	1,870	10,803	11,514	6.2%	93.8%
88-89	475	10	244	98	827	1,949	6,898	1,877	10,724	11,551	7.2%	92.8%
89-90	469	10	256	113	848	2,105	8,132	1,883	12,120	12,968	6.5%	93.5%
90-91	391	10	266	119	786	2,119	7,796	1,884	11,799	12,585	6.2%	93.8%
91-92	354	9	301	115	779	2,293	7,869	1,891	12,053	12,832	6.1%	93.9%

Source: Zaki, Rabiul Hossain, "Analysis of Energy Demand and Household Energy Demand Forecasting: A Case of Bangladesh", Thesis, AIT, Bangkok (1994))
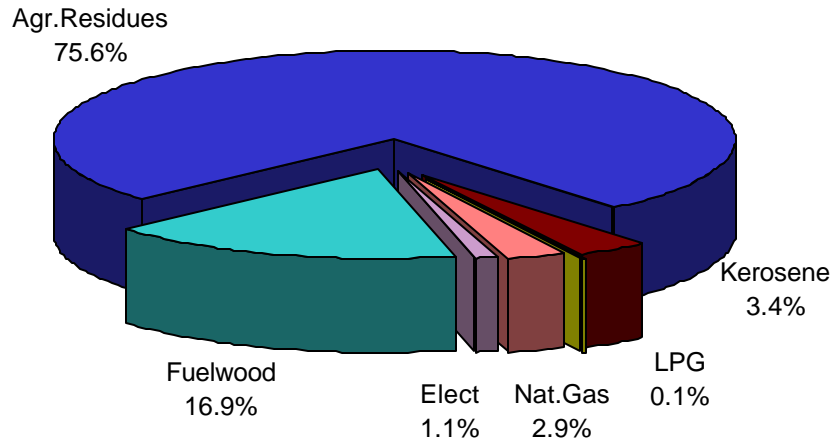
Figure 2.3 Household fuel use pattern in 1992 (Zaki, 1994)

Among the traditional resources, agricultural residues feature predominantly in the residential sector. In 1992, agricultural residues constituted 61.3% of the total traditional energy whereas the share of fuelwood is about 13.7%. Animal dung has a share of 14.7% among the traditional resources.

The rural residential sector consumes about 83.8% of the 1992 total energy consumption. The urban residential sector accounts for the remaining 16.2%. The urban population of Bangladesh constitutes 15.2% of the total population but consumes 85.5% of the conventional fuels.

3. BHUTAN

3.1. The Country

Bhutan rises from an elevation of about 160 meters above sea level in the south to more than 7,550 meters in the north. The climate also varies to the extremes. Bhutan is about 150 km north to south and 300 km east to west and its international boundary of 1,019 km is shared with India (607 km) and China (412 km). But due to the mountainous nature of the terrain, the actual distance is more than twice as long.

The main land forms can be identified as

- Southern foothills rising from the plains to heights of about 1,500 meters extending to the north by about 20 km, with steep, forest covered hills.

- The inner Himalayas gradually rising to 3,000 meters. This is the economic and cultural heartland of Bhutan

- Higher Himalayas in the northern region. This comprises the main Himalayan ranges of snow capped mountains separating Bhutan from Tibet.

Bhutan is the least populated country in South Asia. The population is concentrated in the southern foothills and in the river valleys. The population consists of three main ethnic groups. These are the Sharchops and the Ngalops, collectively known as Drukpas who account for about 65% of the population. By culture and religion they are Tantric Buddhists. Lhotsams, the southern Bhutanese, are mainly Hindus.

3.2. Population and Land Use

The population of Bhutan was estimated in 1985 at 1,417,000 based on the country's first and only census held in 1969. The annual rate of population growth is estimated to be 2.0% based on an annual birth rate of 40 per 1000 during 1975-80. The population is expected to reach 1.9 million by the year 2000. The average density of population is 29 per km^2. Over 97% of the population lives in rural areas. As per FAO (1995), Bhutan's mid 1993 population was 1,500,000.

Out of the total land area of 46,500 square kilometers, about 42.7% is covered with forest with a crown cover of over 40% whereas 14.2% forest is covered with a crown cover of less than 40%. About 25.8% of land cover is estimated to consist of Alpine areas, grasslands and rivers while the remaining 17.3% comprises of agricultural land and other areas.
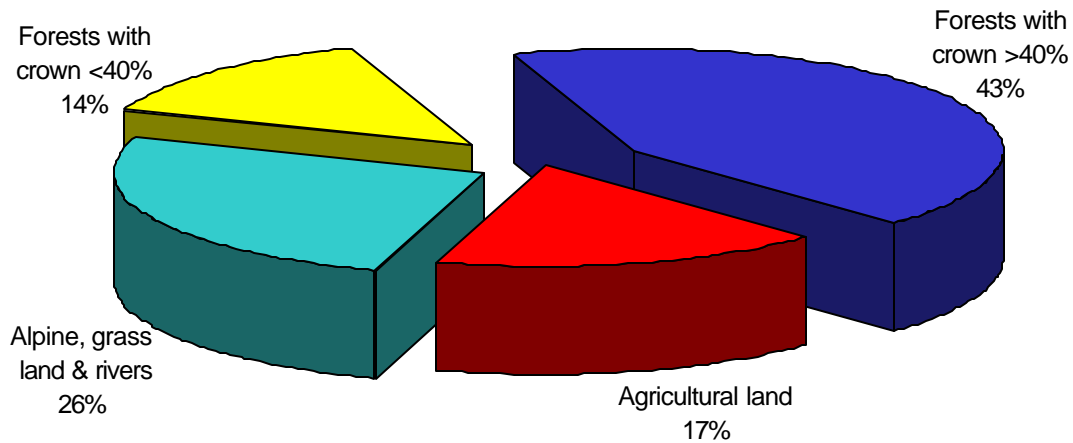
Figure 3.1 Land use pattern

3.3. Economy

Bhutan's economic indicators for the 1985 to 1992 period are given in Table 3.1. Bhutan is one of the 49 low income countries and one of the 29 least developed countries of the world. Bhutan has a free market economy with a predominant private sector. In 1989, exports amounted to 27% of GDP and the imports were 38% of GDP. It is interesting to note that in 1987, the export value showed significant rise due to the export of electricity.

Table 3.1. Major economic indicators (1985-1993)

Economic indicators	1985	1986	1987	1988	1989	1990	1991	1992	1993
GDP (1987 US$ million)	212	233	278	287	295	311	327	339	354
GDP (current US$ million)	193	222	278	283	270	285	242	245	239
GDP growth (%/y)	3.2	10.0	19.4	3.1	2.7	5.6	5.1	3.8	4.5
GNP/cap (1987 US$)	130	140	180	200	200	200	190	180	170

Source: World Tables, World Bank (1995)

About 87.2% of the people in the age group of 15-64 years are engaged in agricultural activities, the main economic activity. The remaining population is employed in government services, business and other occupations. Although Bhutan has considerable mineral resources such as coal, copper, dolomite, graphite, gypsum, lead/zinc etc., the mountainous nature of its locations make their exploitation economically unviable.

3.4. Energy Situation

Since the location of Bhutan is in the Himalayan region with small and sparsely populated villages, the distribution of electricity and oil products is difficult. Apart from that, the climatic and topographical conditions impose high energy requirements. Total production of electric power in the country was 24 GWh in 1983 or 18 kWh per capita. Other forms of conventional energy are not produced.

3.5. Pattern of Energy Consumption:

Major energy sources and the consumption pattern for the 1985 to 1992 period are shown in Table 3.2. Though the share of fuelwood has declined over the years, it is still the major energy source in Bhutan.

Table. 3.2. Share of various fuels consumed (%)

	1985	1986	1987	1988	1989	1990	1991	1992
Electricity	4.1	4.4	5.0	5.9	10.6	10.7	10.8	10.9
Motor gasoline	0.8	0.8	0.8	0.8	0.8	0.8	0.9	0.9
Aviation gasoline	0.1	0.1	0.1	0.0	0.2	0.9	0.9	0.9
Kerosene	0.9	1.1	1.3	1.4	1.3	1.3	1.4	1.4
Diesel oil	5.5	5.9	5.2	4.3	4.3	4.1	4.1	4.1
Furnace oil	0.0	0.0	0.0	0.0	0.8	0.7	0.7	0.7
Biogas	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
LPG	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3
Coal	0.3	0.2	0.2	2.4	2.3	2.2	2.2	2.2
Coke	0.0	0.0	0.3	0.3	0.8	0.8	0.8	0.8
Charcoal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Fuelwood	88.0	87.0	86.5	83.7	78.3	77.8	77.8	76.9
Others	0.2	0.4	0.5	1.1	0.4	0.5	0.1	0.9
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Tshering, Gem, "Sectoral Energy Demand Analysis and Industrial Energy Demand Forecasting for the Kingdom of Bhutan", Thesis, AIT, Bangkok, Thailand (1994)

The energy consuming sectors can be divided into eight categories. These different sectors and their respective shares in energy consumption from 1985 to 1992 are given in Table 3.3.

Table. 3.3 Sectoral energy consumption (% of total)

Sector	1985	1986	1987	1988	1989	1990	1991	1992
Household	85.7	84.6	84.7	82.5	77	76.9	76.9	75.9
Agriculture	0.7	1.2	1.2	1	1.2	1.2	1.2	1.2
Industry	3.9	4	4.7	7.9	13.4	13.1	13.1	14.1
Transport	4.3	4.4	4.5	4.4	4.4	5.2	5.2	5.6
Commercial	0.9	0.2	0.2	0.3	0.3	0.1	0.1	0.2
Government establishments	3.4	3.5	3.5	3.6	3.4	3.3	3.3	3
Energy sector	1.7	2.1	1.2	0.3	0.3	0.2	0.2	0
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

Source: Tshering, Gem, "Sectoral Energy Demand Analysis and Industrial Energy Demand Forecasting for the Kingdom of Bhutan", Thesis, AIT, Bangkok, Thailand (1994)

3.6. Household Energy Consumption

Households comprise the major energy consuming sector and around 95% of the demand is met by fuelwood. In 1989, an overall energy survey was carried out covering the household sector and all energy sources in an attempt to find out the energy consumption pattern as well as cooking, heating and lighting habits in this sector. It was also designed to identify the difficulties and needs of the household energy supply system.

The survey was carried out by P. Hyuonen, with the help of the Department of Education involving 45 primary schools and 14 junior high schools. Three schools were selected from each district of which two were from the rural areas and one from the district headquarters. Also more schools were selected from large districts to give proper representation. Questionnaires were prepared with questions about household cooking, heating and lighting habits and the amount of consumption of various fuels like firewood, kerosene, electricity and cooking gas.

Table 3.4 Household energy consumption by source

Energy Source	Physical volume.	Energy (TJ)	Share (%)
Fuelwood	1,025,000 m^3	8,198	96.4
Kerosene	4,602,000 liters	159	1.9
LPG	694,000 kg	32	0.4
Biogas	3,000 m^3	0.1	0.0
Electricity	12 GWh	118	1.3

Source: Hyuonen, P., "Household Energy Survey Report - 1990", Department of Power, Royal Government of Bhutan (1990)
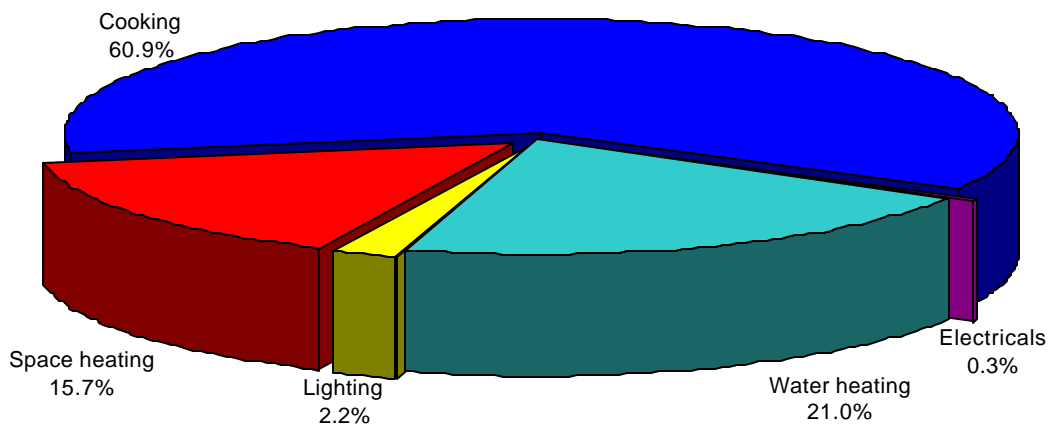
Figure 3.2 Household energy demand pattern (Hyuonen, 1990)

The survey revealed that firewood accounts for about 83.9% of the energy used for cooking, followed by LPG (9.7%) kerosene (5.3%), and electricity (1%). Cooking devices employed and their share in final energy consumption are the firewood chulha (50.4%), the open fire (21.9%) and the improved firewood stove (11.6%). Space heating is mostly done using firewood in an open fire (71.4%) and the firewood bhukari (25.3%). The rest is being done using electricity (3.3%). About 94.3% of water heating is done by firewood, the remaining 5.7% energy is from electricity. The share of kerosene in lighting is 81%, electricity is 10% and 9% is from other sources.

Figure 3.2 shows the energy demand pattern of the household sector. About 61% of the energy requirement is for cooking, followed by water heating and space heating, consuming 21% and 16% respectively.

3.7. The Role of Fuelwood

Since fuelwood is the only readily available source of energy, it is the most used fuel, accounting for 78% of the total energy consumption. As shown in Table 3.5, the major consumer of fuelwood is the household sector with 95%, followed by government and commercial establishments with 3%. The agricultural and industrial sectors consume 0.9% and 0.7%, respectively.

Table 3.5 Fuelwood consumption by sector ('000 m^3)

Sectors	1985	1986	1987	1988	1989	1990	1991	1992
Household	1,004	1,026	1,047	1,068	1,090	1,113	1,115	1,115
Agriculture	6	12	11	8	11	11	12	12
Industry	6	6	6	8	8	9	8	8
Government establishments	35	35	35	36	38	37	37	37
Total	1,051	1,079	1,099	1,120	1,147	1,170	1,172	1,172

Source: Tshering, Gem, "Sectoral Energy Demand Analysis and Industrial Energy Demand Forecasting for the Kingdom of Bhutan", Thesis, AIT, Bangkok, Thailand (1994)

In the agricultural sector, fuelwood is used for cardamom drying. The yearly demand for this purpose is estimated to be 11,000 m^3. Agro industries like beverages and lemon grass oil distilleries require 4,500 m^3 per year. The hand made paper industries use 4,100 m^3 annually. Major consumers in the government sector are schools and the armed forces, estimated at 37,000 m^3. Some fuelwood is consumed in road construction also.

3.8. Fuelwood Resources in Bhutan

The FAO Yearbook of Forest Products contains annual data on the production and trade in forest products for the years 1982 to 1993. According to this reference the total production of fuelwood of Bhutan is as follows (table 3.6).

Table 3.6 Fuelwood production in Bhutan 1985-1993

Year	1985	1986	1987	1988	1989	1990	1991	1992	1993
'000 m^3	1,140	1,165	1,190	1,217	1,244	1,272	1,302	1,332	1,364
ktoe*	261	267	272	279	285	291	298	305	312

*The conversion factor applied is 1 m^3 = 0.23 toe

Source: FAO Yearbook of Forest Products 1982-1993, FAO Forestry Series No. 28, FAO Rome (1995)

4. CAMBODIA

4.1. The Country

Cambodia occupies an area of 18.10 Mha stretching 730 km NE to SW and 512 km SE to NW. The country's coastline on the Gulf of Thailand runs for 389 km. Cambodia shares its international boundary of 2,326 km with Vietnam (982 km), Laos (541 km) and Thailand (803 km).

Table. 4.1 Land and population data

	Unit	1987	1988	1989	1990	1991	1992	1993
Total Land	'000 ha	17,652	17,652	17,652	17,652	17,652	17,652	17,652
Arable + perm. crop land	'000 ha	1,800	1,900	2,099	2,200	2,300	2,400	2,400
Irrigated land	'000 ha	90	92	92	92	92	92	92
Forest + woodland	'000 ha	12,600	12,400	12,143	12,000	11,800	11,600	11,600
Total population	'000	8,070	8,320	8,575	8,841	9,117	9,399	9,683
Agricultural population	'000	5,759	5,899	6,041	6,187	6,338	6,489	6,640
Fuelwood production*	'000 m³	5,026	5,154	5,284	8,421	5,562	5,735	5,880

Source: Country Tables, FAO, Rome (1995)   ** Includes fuelwood converted to charcoal*

Of the total land area of 17,652,000 ha, only 16% was considered agricultural area in 1975 or 0.3 ha per capita. About 65.7% of the total land area of Cambodia is estimated to be under forest cover. A recent survey of land cover types in Cambodia, using remote sensing techniques, revealed the data given in Table 4.2. It shows that the figures for the total land area in 1985/86 and 1992/93 are not consistent with each other and neither with the FAO data.

Table 4.2 Land cover type and extent of Cambodia in 1985/1986 and 1992/1993

Land cover category	Area (km²)	1985-86 (%)	Area (km²)	1992-93 (%)
Tropical rain forest	32,811	21.8	38,408	25.5
Moist mixed deciduous	8,088	5.4	12,718	8.5
Dry mixed deciduous	50,492	33.6	57,756	38.3
Flooded forest	2,459	1.6	15,316	1.0
Marshes	4,270	2.8	4,349	2.9
Mosaic of flooded forest	3,796	2.5	3,779	2.5
Agriculture	20,716	13.8	28,654	19.0
Water bodies	2,543	1.7	2,452	1.6
No data available	25,084	16.8	1,092	0.7
Total	150,259	100.0	164,524	100.0

Source: Land Cover Assessment and Monitoring - Cambodia, Volume 3-A. UNEP, Bangkok (1995)

4.2. Population

The population of Cambodia was estimated at 6,249,000 in 1985, this was based on the last official census held in 1962 when the population was 5,728,771. The population is expected to reach 15.8 million by 2000. The annual population growth rate is estimated at 2.1% on the basis of an annual birth rate of 45.5 per 1000. The population is predominantly rural in character and

nearly 80% is concentrated on the land along the Mekong river. The overall density is 41 per km^2. As per the 1990 population figure the urban population is 12.6% of the total. The average household size is 4.9.

4.3. Economy

Cambodia has a centrally planned socialist economy in which the entire economic sector is public. No literature on the economic parameters of Cambodia is available.

4.4. Energy Situation

Table 4.3 shows production and consumption figures for conventional energy. There is no literature available on the rural energy consumption pattern or even the amount of traditional energy consumed. FAO (1995) gives the amount of fuelwood and charcoal produced for the period of 1987 to 1993, this is shown in Table 4.1.

Table 4.3 Conventional energy consumption and production in Cambodia (ktoe)

Primary energy production	Unit	1989	1990	1991	1992
Solid fuels	ktoe	-	-	-	-
Liquid fuels	ktoe	-	-	-	-
Gaseous fuels	ktoe	-	-	-	-
Electricity	ktoe	5	5	6	6
Total conventional production	ktoe	5	5	6	6
Total consumption	ktoe	155	155	160	164
Per capita consumption	kgoe/capita	19	19	19	19
Fuelwood production	'000 m^3	5,284	5,421	5,562	5,705
	ktoe*	1,210	1,241	1,274	1,306

* A conversion factor of 1 m^3 = 0.23 toe is used

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

5. CHINA

5.1. The Country

China extends about 5,000 km from east to west and about 5,500 km from north to south. The total area is about 959.70 Mha, including 5,000 islands. China has a land boundary of 28,072.6 km which it shares with many countries.

5.2. Population and Land Use

China's population is the largest of all countries in the world. In 1981, nearly one in every four persons on the earth was a citizen of the PRC. As of the year end of 1980, China's population was officially estimated at 982.55 million and had been growing during the previous four years at between 12.5 and 13 million each year. The 1953 census revealed that the sex ratio was 107.6 males per 100 females. The urban content of the population is 13.3% of the national total. As per the land area and the population, the population density is approximately 88 persons per km^2.

Table 5.1. Population and land use data, 1987-93

	Unit	1987	1988	1989	1990	1991	1992	1993
Total population	'000	1,084,628	1,102,168	1,119,186	1,135,089	1,149,608	1,162,980	1,175,537
Agricultural pop.	'000	754,785	759,340	763,138	765,718	766,915	766,978	766,297
Total land	'000 ha	929,100	929,100	929,100	929,100	929,100	929,100	929,100
Arable + perm. crop	'000 ha	95,889	95,720	95,656	95,673	95,654	95,426	95,100
Irrigated land	'000 ha	44,403	44,376	44,917	47,403	47,822	48,590	49,300
Forest + woodland	'000 ha	125,700	124,650	124,650	124,650	128,630	128,630	128,630
Fuelwood production*	'000m^3	177,546	181,097	184,719	188,413	192,171	196,088	199,996

Source: Country Tables, FAO, Rome (1995)   ** Includes fuelwood converted to charcoal*

Most of China is hilly or mountainous. Apart from this the climate is arid in nature with vast reaches, climatically unsuitable for permanent habitation. Only 11% of China's total land area is under cultivation. The prospect of expanding the cultivated area is difficult as most of the land suitable for agriculture is already in use. Overall, 95% of the population of China occupies 45% of the land. About 13.5% of the land area is under forest cover. Tracing the trends of urban and rural distribution of the population of China is very difficult due to a lack of reliable statistical data and the ambiguities in the urban/rural definitions.

5.3. Economy

Public ownership and planning, growing out of socialist ideology and the practical realities of the Chinese economic system were the basic determinants of post 1949 economic institutions. The role of profit in China's economy was limited. The chief mechanism for allocating resources is planning, not the market.

Table 5.2. Major economic indicators of China, 1985-93

Economic Indicators	1985	1986	1987	1988	1989	1990	1991	1992	1993
GDP (1987 US$ million)	210,400	228,177	253,523	282,197	294,004	305,614	331,405	378,921	432,158
GDP (current US$ million)	290,048	280,800	253,523	289,593	323,838	354,952	377,439	418,462	425,611
GDP growth (%/y)	12.9	8.4	11.1	11.3	4.2	3.9	8.4	14.3	14.0
GNP/capita (US$)	350	380	390	400	390	410	440	470	490

Source: World Tables, World Bank (1995)

5.4. Energy Situation

Very few studies on the energy situation in China are available. Table 5.3 gives details of conventional energy production and consumption.

Table 5. 3. Conventional energy production and consumption data

Primary energy production	Unit	1989	1990	1991	1992
Solid fuels	ktoe	526,544	539,402	543,159	557,626
Liquid fuels	ktoe	137,618	138,283	140,968	142,073
Gaseous fuels	ktoe	13,994	14,227	14,943	14,682
Electricity	ktoe	10,180	10,896	10,756	11,390
Total conventional production	ktoe	688,336	702,808	709,826	725,771
Total consumption	ktoe	620,932	625,406	653,114	680,862
Per capita consumption	kgoe/capita	556	552	568	583
Fuelwood production	'000 m^3	184,783	188,477	192,235	203,765
	ktoe*	42,311	43,157	44,018	46,658

* A conversion factor of 1 m^3 = 0.23 toe is used

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

In other data compiled for the UN (REDP, 1989), the pattern of energy consumption in China is given for 1985. About 187.1 Mtoe of traditional energy is consumed in China out of a total of 644.4 Mtoe. Coal consumption constitutes 50% of the total consumption or 318.6 Mtoe. The details are given in Figure 5.1.
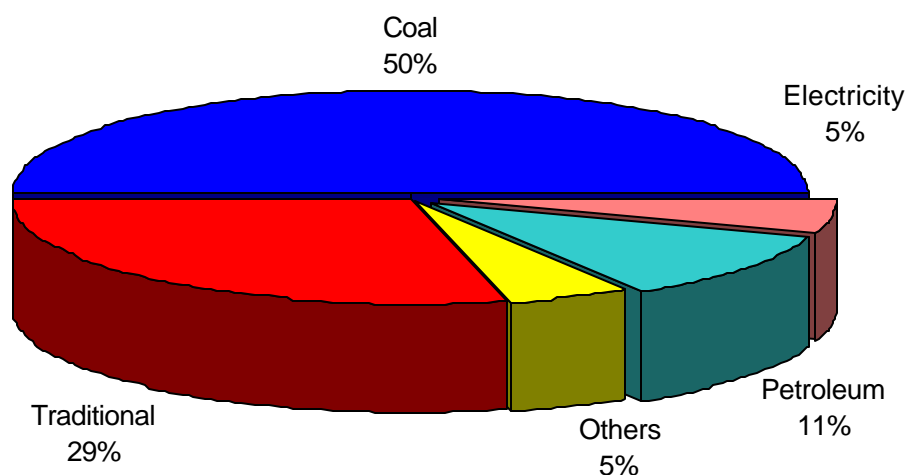
Figure 5.1 Final energy consumption by fuel type in 1985 (REDP, 1989)

An analysis of the various sectors of the economy shows that maximum energy is consumed by the household sector (about 293.5 Mtoe), followed by industry, whose consumption is 257.8 Mtoe.

Table 5.4 Sectoral energy consumption in 1985

Sector	Energy consumption (Mtoe)	Share (%)
Industry	257.7	40.0
Household	293.5	45.5
Tertiary sector	19.7	3.1
Transportation	33.1	5.1
Construction	6.3	1.0
Agriculture	34.2	5.3
Total	644.7	100.0

Source: Sectoral Energy Demand in China, REDP/UNESCAP/ENDP/GOC/GOC (1989)

5.5. Role of Traditional Energy

Traditional energy constituted 29% of the total energy consumed in China in 1985. No data is available on the end uses of traditional energy and the major constituents of traditional energy. It can be reasonably assumed that the major portion of traditional energy is consumed in the rural households.

In 'Forests and Forestry in China' by Richardson (1990), it is mentioned that fuelwood consumption in the Chinese economy is considerable and the demand is growing despite increased production of coal and oil. It is also mentioned that due to the need for fuel in remote areas, many timber forests are being destroyed. Based on statistics published in the Chinese Renmin Baozhi of 13 November 1982, about 134 million m^3 of fuelwood shortage was estimated with an assumed per capita demand of 500 kg annually in rural areas. Even though, due to lack of data, it is difficult to know the extent of fuelwood use and pattern of consumption in China, the

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fact is that an enormous amount of fuelwood is consumed. According to the most conservative estimate, 800 million m^3 of fuelwood is consumed by the rural population alone.

Table 5.5. Fuelwood and charcoal data ('000 m^3)

Item	Production		Import		Export	
	1992	1993	1992	1993	1992	1993
Fuelwood + charcoal	196,152	200,060	191	264	117	162
Fuelwood (coniferous)	79,390	80,977				
Fuelwood (non-coniferous)	116,690	119,023				
Fuelwood (total)	196,080	200,000	31	107	28	103
Charcoal ('000 MT)	12	10	27	26	15	10

Source: FAO Forest Products Yearbook - 1982/1993, FAO, Rome (1993)

China constitutes a large territory encompassing some of the world's major climatic zones. It is also a developing country with a huge population with significant disparities between urban and rural areas; all these factors are reflected in its pattern of energy consumption.

Table 5.6 Per capita yearly energy consumption in urban areas

Year	1981	1982	1983	1984	1985
Consumption (kgoe)	208	213	220	251	331

Source: Sectoral Energy Demand in China, REDP/UNESCAP/UNDP/GOC/GOF (1989)

5.6. Household Energy Consumption

The principal forms of energy used in Chinese households are coal, oil, city gas, electricity, and traditional fuels. Traditional fuels account for over 60% of the total household energy consumption, followed by coal with 35%. The proportions of oil, gas and electricity are very low. The share of traditional fuels and oil is declining while that of coal, gas and electricity in particular, is rising.
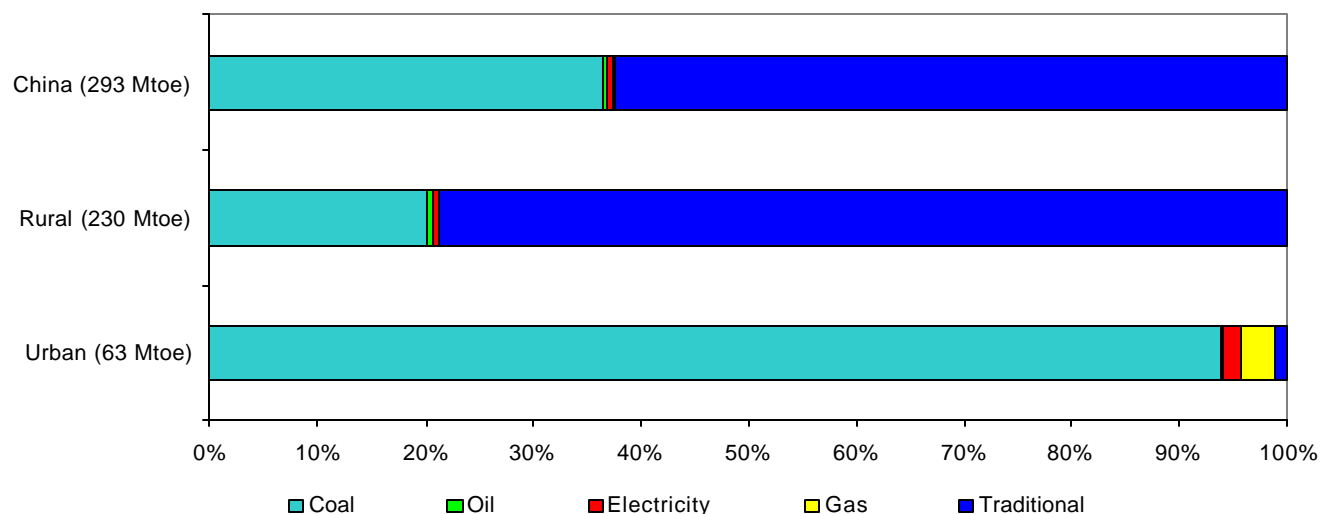

Fig.5.2 Fuel mix in urban and rural households in 1985 (REDP, 1989)

In 1985, 79% of the rural household energy consumption was from traditional fuels whereas in urban households the share of traditional fuels was only 1%. The major fuel used in urban areas is coal.

Table 5.7. Composition of final energy consumption in households, 1985

Urban/Rural	Coal		Oil		Electricity		Gas		Total	
	(Mtoe)	(%)	(Mtoe)	(%)	(Mtoe)	(%)	(Mtoe)	(%)	(Mtoe)	(%)
Urban	59.5	20.3	0.1	0.0	1.1	0.4	2.1	0.7	63.4	21.6
Rural	46.7	15.9	1.2	0.4	0.9	0.3	0.0	0.0	230.0	78.4
Total	106.2	36.2	1.3	0.4	2.0	0.7	2.1	0.7	293.4	100.0

Source: Sectoral Energy Demand in China, REDP/UNESCAP/UNDP/GOC/GOF (1989)

China's household final energy consumption can be divided into five categories of end use: cooking, heating, lighting, electric appliances and air conditioning. Cooking and heating, together make up 99% of the final energy consumption in households.

Table 5.8. End use distribution of final energy by households in 1985

End Uses	Total (%)	Urban (%)	Rural (%)
Cooking	56.3	62.3	54.7
Heating	42.7	36.2	44.5
Lighting	0.6	0.4	0.6
Electric appliances	0.4	0.9	0.2
Air conditioning	0.1	0.1	0.0
Total energy consumption	100.0	100.0	100.0

Source: Sectoral Energy Demand in China, REDP/UNESCAP/UNDP/GOC/GOF (1989)

Household coal is mainly used for cooking, space heating and water heating. City gas includes natural gas, LPG, coal gas etc., this is mainly used for cooking by urban households. Electricity is generally used for lighting and running electric appliances. Oil products, mainly kerosene, are used for lighting. Traditional fuels such as crop stalks, excrement and fuelwood, are largely used in villages for cooking and space heating. A few remote small towns also use crop stalks for cooking.

Table 5.9 Traditional energy sources in rural areas in 1982

Resources	Amount (Mt)	Coal Equivalent (Mt)	% of total
Crop stalks	230	111.7	50.3
Fuelwood	180	103.8	46.8
Manure	10	5.7	2.0
Biogas	N/A	N/A	0.4

Source: Desai, Ashok (Editor), "Energy in China," Energy Research Group, Wiley Eastern Limited (1990)

In China fuelwood originates from fuelwood plantations, windbreaks, "four sides", and timber trees as well as bush, sparse woods, 'economic' forests and bamboo forests. According to Zhen (1994), there are 445,000 rural enterprises and 680-750 million people consuming firewood. The total forest area is 140 million ha: the area devoted to growing trees for fuelwood accounts for 5.5 million ha. The total firewood production is equivalent to 81.62 Mtce/yr. Some 120 million

households employ improved cookstoves with efficiencies of 20-30%. Since the efficiency of traditional stoves was about 10%, some 30-50% of fuel is saved.

The above mentioned reference also quoted that the characteristics of China's household energy consumption are not only low quality fuel but also low efficiency energy devices. For instance, in Northern China, only 5.7% of the total number of houses are heated using efficient (75%) central space heating systems. About 47% of houses use heated bricks and small stoves for heating and these have efficiencies as low as 15-30%. The remaining 47% of heating demand is performed using dispersed boilers with efficiencies of around 55%.

Rural energy is consumed by rural enterprises, for agriculture production and peasants' household uses. Supplies are from conventional energy (coal, fuel oil, gas and electricity) and local resources.

Table 5.10. Final energy consumption in China's countryside in 1983

Source	in energy units 10^6 tce			in physical units
	Household	Production	Total	Total
Crop residues	111	-	111	230 x 10^6 t
Forest fuels	101	3	104	180 x 10^6 t
Dung	4	-	4	8 x 10^6 t
Biogas	1	-	1	10^9 m^3
Total traditional	217	3	220	
Coal	42	66	108	151 x 10^6 t
Oil	24	49	73	8.4 x 10^6 t
Electricity	16	3	19	43.5 TWh
Total conventional	82	118	200	
Grand total	299	221	420	

Source: Smil, Vaclav, Energy in China's Modernisation: Advances and Limitations, Sharpe, Inc. (1988)

During the past decade, great changes in the structure of energy consumption have taken place. The share of the household sector in the final energy consumption has declined by 17%. Correspondingly, that of the production sector has increased: in particular that of rural enterprises has increased by 18%. The share of conventional energy has increased by 19%; correspondingly, that of biomass has decreased. Of rural energy consumption, electricity has increased most quickly (by 80%) promoting the development of the rural market economy and increasing the standard of living.
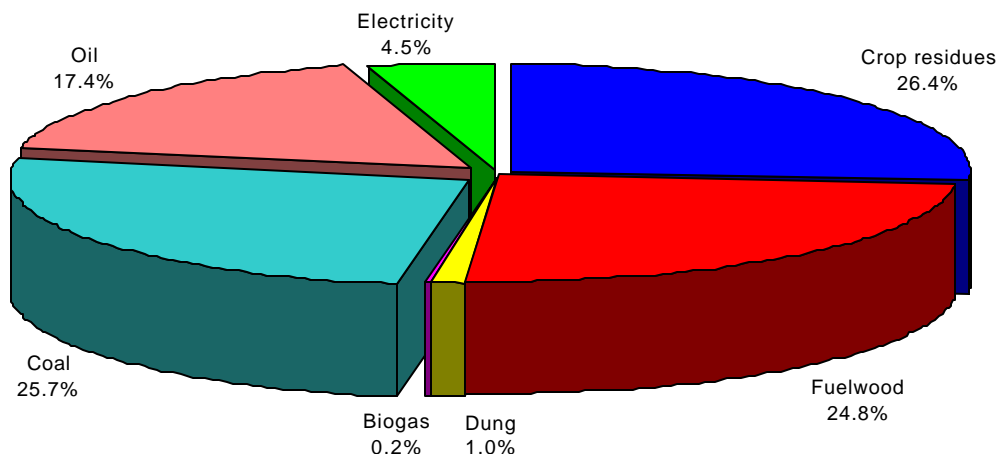
Fig 5.3 Fuel mix in rural areas in 1990

5.7. Fuelwood Resources

Using recent advances in the study of various ecosystems, China's standing phytomass (all above and underground parts of the tree shrubs, grasses, crops and aquatic plants) has been estimated at about 30 billion dry tons, with an annual productivity of around 4.3 billion tons. China's forests are among the world's poorest in resources and productivity. A comprehensive survey in 1976 showed that the total coverage is only 121.6 million ha, constituting only 12.7% of the Chinese territory.

Table 5.11.   Production rates and total production of woodfuels
from different kinds of forests (1990)

Forest type	Production rates			Production (Mtce)
	Mountainous areas in South	Plain and hilly land	Mountain areas in the North	
Fuelwood plantations	7,500 kg/ha	7,500 kg/ha	3,750 kg/ha	21.3
Timber	750 kg/ha	1,050 kg/ha	240 kg/ha	30.4
Windbreak	150 kg/ha	375 kg/ha	525 kg/ha	1.1
Bush	375 kg/ha	525 kg/ha	225 kg/ha	4.4
Sparse	600 kg/ha	840 kg/ha	360 kg/ha	3.8
"Four sides"	2 / tree	2 / tree	2 / tree	13.4
Economic trees	600 kg/ha	840 kg/ha	360 kg/ha	5.8
Bamboo				1.5
Total				81.6

Source: Zhen, Fang, "Rural Energy Resources: Applications and Consumption in China", China Center for Rural Technology Development, Energy Sources, Vol. 16. No. 2 (1994)

Firewood originates from only 4.4% of the total forest areas and comprises about 26% of all woodfuels. Analysis shows that firewood can compete with coal only in areas suitable for firewood growing and when coal is short or where firewood grows with grains, grass or timber forests.

6. INDIA

6.1. The Country

India has a total area of about 328.76 Mha, this includes the Andaman and Nicobar islands in the Bay of Bengal and Lakshadweep in the Arabian Sea. The mainland extends 3,214 km N to S and 2,933 km E to W. The length of the total coastline on the Bay of Bengal, Arabian Sea and the Indian Ocean is about 5,110 km. India shares its total international land boundary of 9,988 km with six neighbors: Bangladesh, China, Nepal, Bhutan, Myanmar and Pakistan.

Mainland India comprises four well defined geographic regions: the northern mountain zone or the Himalayas, the Indo-Gangetic plain, the desert region and the southern peninsula including a narrow coastal plain along the Arabian sea and a broader one along the Bay of Bengal.

India is a tropical country subjected to a wide range of climates from sub-freezing Himalayan winters to 50° C in the shade in the Indo-Gangetic plain, and the highest annual rain fall in the world at Cherrapunji in Meghalaya to the almost permanent rainless Thar Desert of Rajastan.

6.2. Population and Land Use

India ranks second in the world in population, next only to China. It holds 14% of the total world population. Based on a 1981 census, the overall population growth rate is estimated as 1.9%. India ranks 22nd in population density with 232 persons per km^2. The proportion of urban population is about 25.5% and the average household size is 5.6.

Table 6.1 Population and land data

	Unit	1987	1988	1989	1990	1991	1992	1993
Total population	'000	800,913	817,364	833,929	850,638	867,481	884,425	901,459
Agricultural population	'000	511,111	518,830	526,482	534,059	541,549	548,959	556,344
Total land	'000 ha	297,319	297,319	297,319	297,319	297,319	297,319	297,319
Arable+ permanent crop	'000 ha	169,770	169,310	169,485	169,438	169,340	169,650	169,650
Irrigated land	'000 ha	42,490	43,050	44,853	45,144	46,000	47,000	48,000
Forest+ woodland	'000 ha	66,750	66,860	67,084	67,762	67,990	68,500	68,500
Fuelwood production *	'000m^3	233,936	238,569	243,247	248,017	252,868	257,789	262,782

Source: Country Tables, FAO, Rome (1995)   ** Includes fuelwood converted to charcoal*

About 57% of the total land area is under permanent crop and about 23% is under forest cover. Also, 16% of the total land area is irrigated. The details are given in the Table 6.1.

6.3. Economy

The public sector still predominates the Indian economy, although in recent years the country has been trying to open up the economy to give the private sector a free hand. The major economic indicators for India for the years 1985-92 are given in Table 6.2.

Table 6.2. Principal economic indicators (1985-1993)

Economic indicators	1985	1986	1987	1988	1989	1990	1991	1992	1993
GDP (1987 US$ million)	233,973	245,300	256,933	282,510	301,124	316,759	319,131	333,712	343,124
GDP (curr. US$ million)	214,308	229,061	256,933	273,384	274,153	297,133	251,093	267,739	250,966
GDP growth (%/y)	5.4	4.8	4.7	10.0	6.6	5.2	0.7	4.6	2.8
GNI/capita (1987 US$)	310	310	320	350	360	370	360	370	370
GNI growth (%/y)	5.5	5.0	4.1	10.3	6.1	4.3	0.7	4.5	2.3
GNP/capita (US$)	280	290	330	380	370	370	330	330	300

Source: World Tables, World Bank (1995)

6.4. Energy Situation

In 1991, primary energy production in India was in the range of 356-425 Mtoe of which biomass fuels held a 36 to 46% share. Coal is the dominant conventional source of energy followed by oil. Fuelwood is the most prominent biomass fuel. Compared to OECD countries where the total primary energy use per capita is around 200 GJ/capita/yr, India has a very low per capita consumption of about 17.7-21.1 GJ/capita/yr.

Table 6.3. Primary conventional energy production and consumption, 1989-92

Primary energy production	Unit	1989	1990	1991	1992
Solid fuels	ktoe	118,131	120,530	135,103	141,944
Liquid fuels	ktoe	34,274	34,179	32,016	28,456
Gas fuels	ktoe	7,543	9,284	10,469	10,886
Electricity	ktoe	6,546	7,761	7,711	7,763
Total conventional production	ktoe	166,493	171,754	185,300	189,050
Total consumption	ktoe	180,708	188,448	202,715	215,457
Per capita consumption	kgoe	218	223	235	245
Fuelwood production*	'000 m^3	243,247	248,017	252,868	257,789
	ktoe*	55,698	56,791	57,901	59,028

*Includes fuelwood converted to charcoal, conversion ratio assumed: 1 m^3 wood = 0.23 toe

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

The Indian industrial sector consumes most of the conventional fuels followed by the transport sector. These sectors consume 51 and 22% of the total conventional energy, respectively. The share of the residential sector is about 13.1 Mtoe or 10% of the total energy consumed. Petroleum products and electricity are the conventional fuels used in this sector.

Table 6.4 gives sector-wise consumption of conventional fuels. It appears that the figure for the total consumption is lower than the one given in table 6.3, which may be due to the exclusion of biomass fuels.

Table 6.4. Sectorwise conventional energy consumption in India -1993/1994 (Mtoe).

Sector	Coal	Natural gas	Petroleum products	Electricity	Total
Agriculture	0.0	0.1	0.8	6.0	6.9
Industry	51.9	1.4	9.7	8.0	71.0
Transport	0.8	0.0	30.3	0.5	31.6
Residential	0.0	0.1	10.3	3.6	14.0
Other uses	0.0	0.0	2.2	2.0	4.2
Non energy use	0.0	5.7	7.0	0.0	12.7
Total	52.7	7.3	60.3	20.1	140.4

Source: TERI Energy Data Directory & Yearbook, 1995/96, TERI, India (1996)
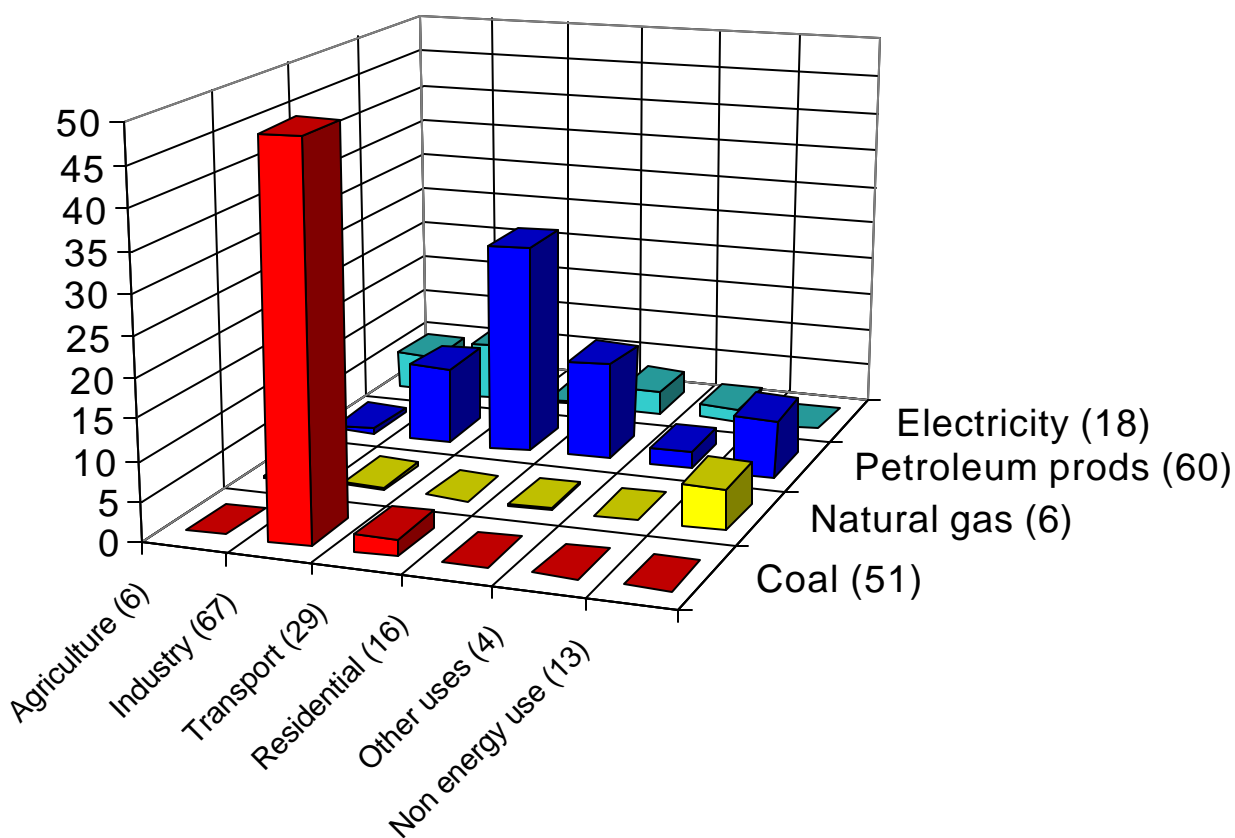
Fig. 6.1 Share of various sectors in energy consumption (Mtoe).

Source: TERI Energy Data Directory & Yearbook, 1995/96, TERI, India (1996)

In general, with economic development there is a shift in the pattern of energy use from biomass fuels to fossil fuels and electricity. Hence one would have expected that the dependence on biomass energy in India would have declined with the country's economic development. However, studies over a period of 20 years in retrospective show that the use of biomass energy sources such as fuelwood, crop residues and dung has increased considerably. Rural population growth and the absence of alternative fuels are the main reasons for this.

Most of the biomass energy is used in the domestic sector in both the urban and rural areas. Fuelwood is the dominant fuel source, though dung and agricultural residues are also widely used. Fuelwood is also used in many urban households. Dung is only used in the domestic sector, but crop residues are used in the industrial sector as well. During the year 1991, traditional fuels delivered some 46.5% of the total energy consumption.

Studies have revealed that fuelwood and other traditional fuels are used in all villages to such an extent that sometimes 99% of the energy requirements are met by them. Studies have also revealed that if fuelwood is available, households prefer it to crop residues and dung.

Table 6.5. Traditional energy consumption in India (1991)

Fuels	Using mean estimate for biomass			Using low estimate for biomass		
	Quantity (Mt)	Total (PJ/yr)	Per capita (GJ/yr)	Quantity (Mt)	Total (PJ/yr)	Per capita (GJ/yr)
Fuelwood	298	4,470	5.3	227	3,405	4.0
Crop residues	156	2,267	2.7	97	1,500	1.8
Dung	114	1,562	1.9	37	507	0.6
Total biomass	568	8,299	9.8	361	5,412	6.4
Total energy		17,862	21.1		14,975	17.7
		425 Mtoe	0.5 toe		356 Mtoe	0.4 toe

Source: Ravindranath, N.H. & D.O. Hall, "Biomass, Energy and Environment, A Developing Country Perspective from India", Oxford University Press (1995)
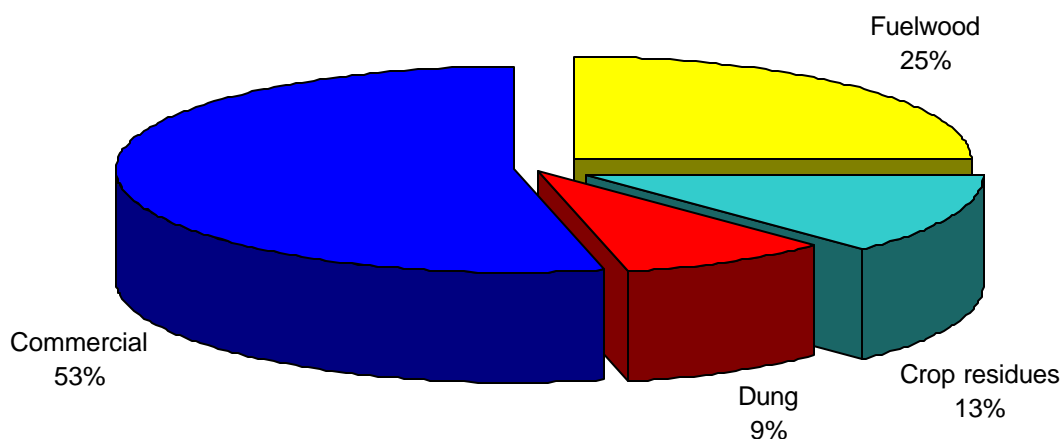
Fig. 6.2 Share of traditional fuels in total energy consumption

Table 6.6. Energy usage patterns in selected villages in India (% share).

Energy source	Maulaganj (North)	Bishnupur (South)	Dhanwas (North)	Nanuda (West)	Ungra (South)	BNPura (East)
Wood	38.9	95.0	8.0	30.2	43.5	49.9
Crop Res	24.1	3.8	19.0	37.4	42.0	2.2
Dung	32.6	-	65.2	11.4	-	32.1
Total traditional	**95.6**	**98.8**	**92.2**	**79.0**	**85.5**	**84.2**
Kerosene	2.3	1.2	0.9	8.7	2.1	1.1
Diesel	2.1	-	4.4	0.9	-	0.5
Electricity	-	-	2.5	11.4	2.7	0.3
Total conventional	**4.4**	**1.2**	**7.8**	**21.0**	**4.8**	**1.9**
Others	-	-	-	-	9.7	13.9
Total energy	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Table 6.6 clearly demonstrates that in different regions of India traditional energy dominates the village matrix and also there are no major differences in the share of traditional and conventional fuels in different geographic locations.

Table 6.7 Biomass energy use in selected villages of India (GJ/capita/y)

Energy Source	Maulaganj	Bishnapur	Dhanwas	Nanuda	Ungra	BNPura
Wood	4.4	10.4	0.8	2.2	4.2	9.6
Crop residues	2.7	0.4	1.8	2.7	4.1	0.4
Dung	3.7	-	6.2	0.8	-	6.2
Total biomass	**10.7**	**10.8**	**8.7**	**5.7**	**8.3**	**16.2**
Kerosene	0.3	0.1	0.1	0.6	0.2	0.2
Diesel	0.2	-	0.4	0.1	-	0.1
Electricity	-	-	0.2	0.8	0.3	0.1
Total conventional	**0.5**	**0.1**	**0.7**	**1.5**	**0.5**	**0.4**
Animal					0.1	1.0
Human					0.8	1.7
Total energy	**11.2**	**10.9**	**9.5**	**7.2**	**9.7**	**19.3**
Population	1,143	931	833	838	1,047	593

Fuelwood is also used in rural industries such as brick and tile making, lime manufacturing and tobacco curing. Crop residues are also widely used. It should be noted that the use of fuelwood in major industries like brick and tile manufacturing is slowly being replaced by coal and rice husk. Though these rural industries are not dominant fuelwood users, they should be included in any efforts intended for conservation of wood.

Table 6.8. Sectoral and per capita biomass energy use in India (1991)

Type of biomass	Domestic (Mt/yr)[a]		Industrial (Mt/yr)		Total	Per capita
	Rural	Urban	Rural	Urban	(Mt/yr)	(GJ/y)
Using mean estimate						9.82
Fuelwood	252	30[b]	6[c]	10[d]	298	5.29
Crop residue	99	-	-	57[e]	156[f]	2.68
Dung	109	5	-	-	114	1.85
Using low estimate						6.40
Fuelwood	181	30	6	6	227	4.03
Crop residue	40	-	-	-	97	1.77
Dung	32	5	-	-	37	0.60

[a]   Domestic sector involves mainly cooking.
[b]   Urban fuelwood use in domestic sector, using per capita estimates of Ranganathan et al. (1993) and the 1991 urban population
[c]   6 Mt for brick industry in rural areas.
[d]   Urban fuelwood use 10 Mt.
[e]   Sugarcane bagasse production in 1991-92 of 82 Mt fresh = 779 PJ (at 19 GJ/t). Rice husk production in 1991 was 16 Mt = 201 PJ (12.6 GJ/t). Total energy value (of 57 Mt) = 980 PJ.
[f]   Crop residue energy value =779 PJ of cane bagasse + 201 PJ of rice husks + 1287 PJ of crop residue as domestic fuel (99 Mt at 13 GJ/t) = 2267 PJ for 'mean estimate'. Similarly, for 'low biomass estimate' = 779 PJ of cane bagasse + 201 PJ of rice husks + 520 PJ of crop residue (40 Mt at 13 GJ/t) = 1500 PJ

Source: Ravindranath, N.H. & D.O. Hall, "Biomass, Energy and Environment, A Developing Country Perspective from India", Oxford University Press (1995)

6.5. Regional Rural Energy Surveys:

With the size of the country there are large variations in climate vegetation type, ranging from tropical moist evergreen forests to dry deciduous forests and temperate montane forests. Consequently, biomass usage patterns vary with local climate, vegetation type, fuelwood availability and access to fuelwood. India has been classified into 15 agro-climatic zones. The details of variation in types and extent of biomass fuel use are given in Table 6.9.

Table 6.9. Biomass fuel use in various agro-climatic zones in India

Agro climatic zones	Fuelwood (kg/capita/day)	Dung (kg/capita/day)	Crop residue (kg/capita/day)	Energy value (GJ/capita/day)
Western Himalayan	1.1	0.2	-	6
Eastern Himalayan	1.9	0.2	0.4	13
Lower Gangetic	1.9	0.6	0.6	10
Middle Gangetic	0.5	0.4	0.3	5
Upper Gangetic	0.3	1.3	0.1	8
Trans Gangetic	0.4	0.6	0.3	6
Eastern plateau & hills	3.4	0.1	0.2	19
Central plateau & hills	1.0	0.7	0.3	9
Western plateau & hills	1.0	0.2	0.5	8
Southern plateau & hills	0.9	0.3	0.8	10
East coast plains & hills	1.8	0.9	1.4	20
West coast plains & hills	0.9	0.2	0.1	6
Gujarat plain and hills	0.9	0.2	0.3	7
Western dry regions	0.6	0.6	0.1	6

Source: Ravindranath, N.H. & D.O. Hall, "Biomass, Energy and Environment, A Developing Country Perspective from India", Oxford University Press (1995)

With diverse socio-cultural backgrounds, the pattern of energy use also differs in various geographical regions of India. In that context, three regional surveys carried out in the south, north and eastern part of India can provide an insight in to the pattern of rural energy consumption.

A study was conducted in the Tehri district in the Garhwal region of Uttar Pradesh between September 1987 and March 1989, in 583 households both in summer and winter seasons. The area of the Tehri district is about 4,421 km^2. The forest cover of the Garhwal region is 22,791 km^2 out of a total geographical area of 30,090 km^2. Although fuelwood is the main source of energy for the majority of the families in this district, there is no reliable information on the consumption pattern of biomass and other sources of energy here.

Cooking, lighting, water heating and space heating are the major energy consuming activities in the household sector. In the rural areas, most of the energy is used for cooking and lighting, while in urban areas space and water heating requirements must also be met. Although fuelwood is also used in urban areas most of it is purchased from the market. Some urban families also collect wood from nearby forests. However, in the majority of urban areas, the energy demand is met by conventional fuel supplies such as kerosene, LPG and electricity. The difference between the fuelwood consumption in summer and winter is due to the need for space heating during winter. The majority of the rural sector households gathered their fuelwood from nearby forests. This collection involves 5-10 km distances. The most commonly employed cooking device in rural areas using biomass fuels is the mud stove, made from stone and mud on the floor. Industrial fuelwood use is negligible in this region.

Table 6.10. Wood energy consumption pattern in the northern hills (kg/person/year)

Elevation (m)	Rural/Urban	Summer	Winter	Round year
500-1,000	Urban	0.8	0.9	307
	Rural	1.4	1.6	544
1,000-1,500	Rural	1.1	1.4	464
1,500-2,000	Rural	1.3	1.8	569
2,000-	Rural	1.2	2.9	761
Total/average		1.25	1.95	584

Source: Negi & Todaria, "Studies on the Impact of Local Folk on Forests of Garhwal Himalaya 1: Energy from Biomass", Biomass and Bioenergy Vol. 4, No.6.(1993)

In order to analyze the energy dimensions in agricultural activities and small scale rural activities, another large field study was carried out in rural Karnataka, a state in the southern part of India. Eight villages were carefully selected to reflect the geographic, climatic, biomass resource and socio-economic features of Karnataka.

As is to be expected, the coastal region with its heavy rainfall, forested areas and higher biomass production was found to be the highest consumer of biomass fuels and the semi-arid north the lowest. While in the coastal and southern parts the middle class is the major consumer of energy, in the north it is the working class that consumes the most.

Table 6.11. Household traditional fuel consumption in rural Karnataka (kg/capita/y)

Fuel	Region	Middle class	Small holder class	Labor class
Fuelwood	North	134	97	56
	South	297	278	113
	Coastal	539	332	158
Non fuelwood	North	209	217	340
	South	299	259	329
	Coastal	343	237	342
Dung	North	56	58	61
	South	6	38	26
	Coastal	-	47	44
Total Biomass	North	399	372	439
	South	600	575	468
	Coastal	882	616	584

Source: Bhagavan & Giriappa, "Biomass, Energy and Economic and Natural Resources Differentiation in Rural Southern India", Biomass and Bioenergy, Vol. 8, No. 3. (1995)

In yet another study carried out in the eastern state of Orissa in 1987-88, it was found that about 85.2% of all fuels used in the region were traditional fuels. A major share (89%) of the consumption was for cooking and the rest (11%) was accounted for by kerosene and electricity for lighting. Among the traditional sources of energy firewood accounted for 73% of the total consumption followed by dung (9%) and agricultural wastes (3%). Among the conventional fuels, kerosene accounted for the major share (7%) followed by electricity (6%), coal (2%) and LPG (0.2%)

The major portion of fuelwood consumption in the region was in the form of twigs, shrubs and small thin tree branches collected from nearby forests and wood lots. Approximately 86% of the fuelwood is used in the form of twigs and shrubs. Bigger branches and logs constitute the remaining 14%. In some places roots of shrubs are also used as fuel. Logs and bigger thick branches of trees are used only when the fuel is purchased. Many people, especially those living in the tribal hamlets earn their livelihood by selling wood twigs and branches in the nearby market areas. They bring the wood in big bundles, skin the branches and cut them into small bundles of about 1 kg weight. Every bundle consists of approximately 20-30 sticks of 30-35 cm length and 1-2 cm diameter and is sold for Rs. 0.50 to 0.70. People walk as much as 3-6 km to collect fuelwood and spend 3 to 6 hours to gather it.

6.6. Major End Uses of Traditional Energy

Traditional energy is used in the domestic sector for cooking and heating bath water both in rural and urban areas, and also in industries and establishments. A national level study carried out in 1978-1979 revealed that 51% of the fuel used in rural areas is fuelwood, 16% crop residues, 21% dung and 12% other fuels (including conventional fuels). In urban areas, fuelwood constitutes 35% of energy consumption, dung 4% and others 61%.

On the national level various wood consumption estimates exist, ranging from 93 Mt/y (110 kg/capita/y) to 309 Mt/y (492 kg/capita/y) for cooking alone. Crop residues and dung are also used for cooking. Most of the studies on biomass use in the domestic sector are restricted to

cooking alone. This may be due to the fact that only 4% of the household energy consumption is accounted for heating bath water as compared to 88% for cooking.

Though traditional fuels, mostly fuelwood and dung, are used in the urban households also, the trend is moving towards using more conventional fuels. Studies also show that the majority of fuelwood sold in urban areas is in the form of wood cuts from trees and large branches, obviously from the felling of trees. This may have some implications for forest degradation and deforestation.

6.7. Fuelwood Use in Industries and Establishments

Fuelwood is used for manufacturing housing materials such as bricks, tiles and lime, and in agro-processing such as jaggery preparation, tobacco curing and preparation of spices like cardamom. In rural areas nearly all building construction materials are fired using fuelwood. As a result of increasing wood prices, brick manufacturing for the urban market is increasingly being done using coal and rice husks. Urban establishments are estimated to account for 22% of total fuelwood use in large cities and about 45% in moderate sized towns. The details of fuelwood use in two major cities are given in Table 6.12.

Table 6.12 Fuelwood use in urban industrial/institutional sectors (% of total)

Industry/establishment	Bangalore (total 102 kt/y)	Hyderabad (total 116 kt/y)
Hotel	18%	21%
Bakeries	19%	22%
Hostels	9%	4%
Crematoria	4%	2%
Marriage halls	8%	4%
Industries	41%	47%
Others	1%	0%
Total	100%	100%

Source: Ravindranath, N. H. & D. O. Hall, "Biomass, Energy and Environment, A Developing Country Perspective from India", Oxford University Press (1995)

Results of a recent study conducted to measure the efficiency using standard tests for different biomass fuels in traditional and improved stoves are given in Table 6.13.

Table 6.13 End use device efficiencies

Type of end use device	PHU (%)
Dung, traditional stove	11.1
Fuelwood, trad. stove	14.4
Open fire	15.6
Charcoal stove	23.2
Fuelwood Astra stove	34.2

Source: Ravindranath, N. H. & D. O. Hall, "Biomass, Energy and Environment, A Developing Country Perspective from India", Oxford University Press (1995)

6.8. Sources of Fuelwood

Fuelwood can be derived from different sources such as forests, degraded forests, tree plantations, strips or rows of trees along roads/streams/railway lines, canals/cropland boundaries, common lands or homestead gardens. The annual use of fuelwood is estimated to be 227 Mt/y, out of which 181 Mt is used in the domestic sector for cooking in the rural areas.

Various fuelwood sources and their respective contributions have been tabulated in Table 6.14. India has an estimated 64 Mha of forest area which holds a total standing biomass of 8,057 Mt. The annual increment for the forest is 138 Mt out of which 42 Mt are twigs and branches. The total area established under plantations is around 17 Mha. Most of the tree plantations are on village commons, farmer's land, and trees planted along side roads, canals, and streams. The contribution from afforested plantations to the fuelwood supplies is estimated to be 40 Mt/yr. According to the National Sample Survey, private house gardens and trees around the houses are estimated to provide 30 Mt of fuelwood annually in India. No studies are presently available on the vegetation status and contribution of village commons.

Table 6.14 Sources of fuelwood used in the household sector

Sources	Details	Fuelwood contribution	
		Mt/y	%
Forests (> 10% Crown), 64 Mha	Felling of trees	19.0	8.7
	Lopping of twigs and branches in existing forests	42.0	19.2
	Logging wastes	9.5	4.3
Tree plantation[a],17 Mha	Tops, twigs, small branches, poles	40.0	18.3
Farm trees[b]	Twigs, branches	46.0	21.1
Homestead gardens[c]	Twigs, branches	16.0	7.3
Degraded lands[d], 52.8 Mha	0.5 t wood/ha/yr	26.4	12.1
Land for shrub estimation	78.5 Mha at 0.25 t/ha/yr	19.6	9.0
Total wood supply		218.5	100.0

Source: Ravindranath, N. H. & D. O. Hall, "Biomass, Energy and Environment, A Developing Country Perspective from India", Oxford University Press (1995)

[a] Tree plantations include farm forestry (on farm land) + Forest Department (FD) forestry (on degraded forest land) + community forestry (on village commons). Tree plantation = farm forestry (8.5 Mha) at 4.2 t/ha/yr + community forestry and FD forestry (8.5 Mha) at 2.6 t/ha/yr. Of the total annual productivity of 57.8 Mt, a maximum of 17.8 Mt is assumed to be used as industrial and structural wood and the rest is assumed to be used as fuel.

[b] Farm trees: rows of trees along crop land boundary and bunds.

[c] Homestead gardens: trees around homes.

[d] Degraded lands = degraded forest < 10% tree crown (11.2 Mha) + permanent pastures (11.8 Mha) + miscellaneous traditional tree groves (3.5 Mha) + cultivable waste land or fallow (15.2 Mha) + other fallow (11.1 Mha) = 52.8 Mha.

[e] Land for shrub production = 52.8 Mha of degraded land + 25.7 Mha of open forests with (10-40% tree crown).

7. INDONESIA

7.1. The Country

Indonesia consists of 13,667 islands of which only 1,000 are inhabited. Five of the islands (Java, Sumatra, Sulawesi, Kalimantan and Irian Jaya) account for 90% of the land area. The total length of the coastline is 36,616 km and the greatest distance east-west is 5,271 km and north-south 2,210 km. Its land boundaries are shared by Malaysia (1,496 km) and Papua New Guinea (777 km). Of all the islands, Irian Jaya and Sulawesi are the most mountainous, but each island has its own coastal and mountainous regions.

7.2. Population and Land Use

The population of Indonesia in 1985 was 173.1 million, the fifth highest in the world based on the official census in 1980 when the population was 147.5 million. As per the census of 1990, the population is 179.4 million. The population is expected to reach 227 million by the year 2000. The annual growth rate is estimated to be 1.76% for the population as a whole and 4.4% for the urban population. Indonesia has an urban population of 31%. The average household size is 4.8 persons. Indonesia has the highest population density in Southeast Asia. In Java and Madura the average exceeds 540 per km^2 while in Irian Jaya it is 1.9 per km^2. The national average is 87 per km^2 and for the agricultural areas it is 461.2 per km^2.

Indonesia has a total land area of about 181 Mha out of which 18.2% is under permanent crops and 2.5% is irrigated. About 61.6% of the land is under forest cover and woodlands, but the percentage of crown cover is unknown.

Table 7.1 Population and land data

	Unit	1987	1988	1989	1990	1991	1992	1993
Total population	'000	173,658	176,746	179,794	182,812	185,793	188,740	191,671
Agricultural	'000	81,681	81,581	81,415	81,191	80,910	80,572	80,185
Total land	'000 ha	181,157	181,157	181,157	181,157	181,157	181,157	181,157
Arable + perm. crop	'000 ha	30,644	31,418	31,142	31,973	28,941	33,051	30,987
Irrigated land	'000 ha	4,300	4,300	4,387	4,410	4,432	4,500	4,597
Forest + woodland	'000 ha	111,600	111,000	110,400	111,775	111,000	111,000	111,774
Fuelwood production*	'000 m³	133,184	135,782	138,387	141,007	143,643	146,320	149,063

Source: Country Tables, FAO, Rome (1995)   **Includes wood converted to charcoal.*

7.3. Economy

Though Indonesia is a low income country, during the past few years it has made strides in economic development. It has a free market economy with a predominant private sector. The major economic indicators of Indonesia for the years 1985 to 92 are given below:

Table 7.2. Major economic indicators (1985-92)

Economic indicators	1985	1986	1987	1988	1989	1990	1991	1992	1993
GDP (1987 mill. US$)	68,426	72,396	75,932	80,340	86,283	92,361	98,553	104,935	111,585
GDP (curr. US$ mill.)	87,338	80,059	75,932	84,301	94,452	106,141	116,623	128,027	144,707
GDP growth (%/y)	2.6	5.8	4.9	5.8	7.4	7.0	6.7	6.5	6.3
GNI/capita (1987 US$)	420	410	430	430	460	480	500	520	550
GNI growth (%/y)	4.0	0.6	4.5	2.9	7.7	6.5	6.0	5.9	6.0
GNP/capita (US$)	520	530	520	530	540	570	620	680	740

Source: World Tables, World Bank (1995)

7.4. Energy Situation

In 1982 Indonesia's energy production and consumption reached 118,218 and 36,534 ktce respectively, or a per capita consumption of 233 kgce. Its exports totaled 102,133 ktce in that year. Indonesia is totally dependent on oil for its power. It has 16 billion barrels of recoverable reserves of petroleum and 34.7 trillion m^3 or recoverable reserves of natural gas.

Table 7.3. Primary energy production and consumption, 1989-92

Primary energy production	Unit	1989	1990	1991	1992
Solid fuels	ktoe	3,187	5,129	9,600	14,802
Liquid fuels	ktoe	69,318	71,513	72,382	73,727
Gas fuels	ktoe	34,930	37,703	43,456	48,286
Electricity	ktoe	920	950	915	933
Total conventional production	ktoe	108,355	115,294	126,354	137,748
Total consumption	ktoe	39,512	40,306	45,720	51,244
Per capita consumption	kg/capita	218	219	244	268
Fuelwood production	'000 m^3	138,387	141,007	143,643	146,278
	ktoe*	31,688	32,288	32,891	33,495

*A conversion factor of 1 m^3 wood = 0.23 toe was used

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

Indonesia is rich in conventional energy sources as well as traditional energy sources. Since Indonesia consists of many islands with different ecosystems and cultures, it is difficult to estimate the true situation in regard to biomass energy supplies.

Both the households and industries use fuelwood, charcoal, kerosene, LPG and electricity. But households typically use fuelwood and kerosene, while most industries use electricity or gas.

Table 7.4. Traditional energy balance of Indonesia-1992 (ktoe)

	Wood	Charcoal	Other biomass	Total traditional	Total energy	% share of traditional
Gross primary supply	20,951	0	5,596	26,547	139,437	19.0
Net domestic supply	20,933	0	5,596	26,529	71,177	37.3
Net domestic consumption	20,934	6	5,596	26,536	67,647	39.2

Source: Asian Energy Review, Vol. 4, May 1994, ASEAN-EC Energy Management Training and Research Center (1994)

Wood (20,934)

Commercial
(41,111)

Charcoal (6)

Other biomass
(5,596)
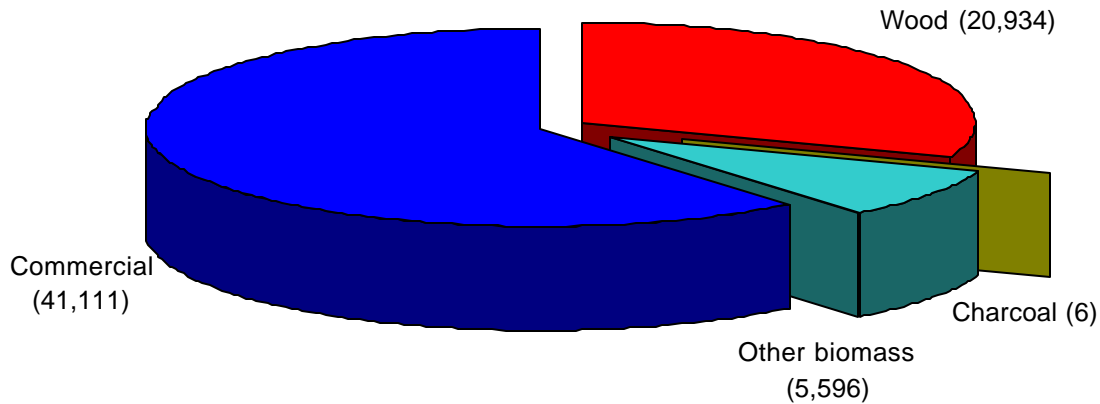
Fig 7.1 Share of traditional and conventional energy consumption - 1992 (AEEMTRC, 1994)

7.5. Traditional Energy

A number of surveys have been conducted by various agencies in different parts of Indonesia in order to know the dynamics of the country's energy supply and consumption. These surveys were carried out both in urban and rural contexts for conventional as well as traditional energy sources. One such survey, carried out in West Java in 1986, revealed data on the fuelwood potential and supply outside the forest land and large commercial agricultural estates. About 70-80% of the population in the region is rural and found distributed over about 7,000 villages. Fuelwood is mainly used for cooking and about 0.5 to 1.2 m^3 per capita per year is used only for cooking and heating purposes. Village industries such as brick and tile making, lime burning, ceramics industry and charcoal making also use fuelwood. In every batch of product, about 10-40 m^3 of fuelwood is consumed. The origin of the fuelwood in West Java is given in Table 7.5.

Table 7.5 Land use types and fuelwood supply in West Java

Land use type	Supply (m^3/ha/yr)	Annual supply	
		('000 m^3/yr)	(TJ)
Mixed gardens	27	18,705	85.4
Home gardens	22	6,835	12.0
Crop fields	18	5,102	63.8
Other	6	1,525	233.8
Rice fields	2	961	19.1

Source: Regional Energy Development Project of West Java, REDEP Phase II, Vol. I, January 1988

The fuelwood is generally collected from fruit trees (jack fruit, durian, lemon, soursop), timber trees (abizia falcataria, mahogany, sesbania grandiflora, alstonia scholaris) and shrubs, by means of pruning, lopping, thinning and cutting down. The proportion of the total annual fuelwood supply is 22% of the total fuelwood potential or 15% of the total biomass potential.
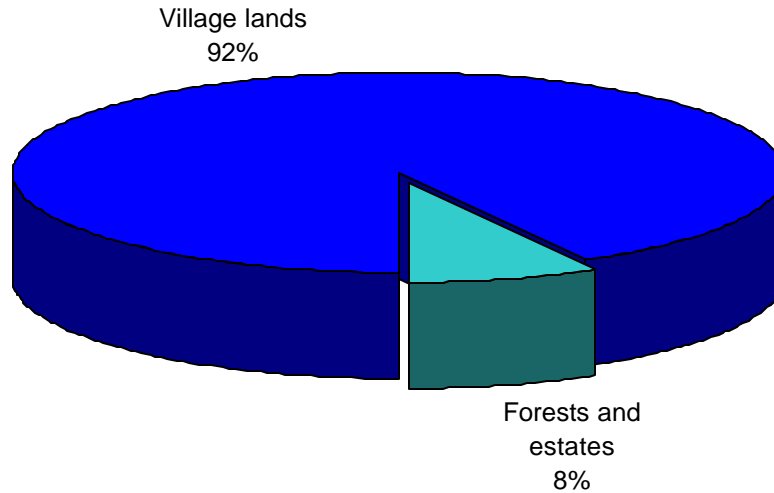
Figure 7.2 Woody biomass by source in West Java, 1986 (REDEP, 1988)

The majority of rural households in West Java use biomass in the form of fuelwood, twigs, shrubs and species that are not technically trees, e.g. bamboo and coconut palms (REDEP, 1988). As much as 83% of the total biomass used by the rural population is collected from the village lands and cultivated fields, whereas only a small percentage is obtained from forests (less than one percent) and rubber estates (6%). Rice husks and other agricultural wastes, excluding rice straw, provide the remaining 10% to the total biomass supply. 21% of the wood supply from village lands is provided by home yards, 56% by mixed gardens, 15% by dry agricultural land, and 8% by other land. Woody biomass (90% of the total biomass supply) consists of fuelwood, twigs shrubs and so on, of which 93% comes from village land and 7% from forests and rubber estates.
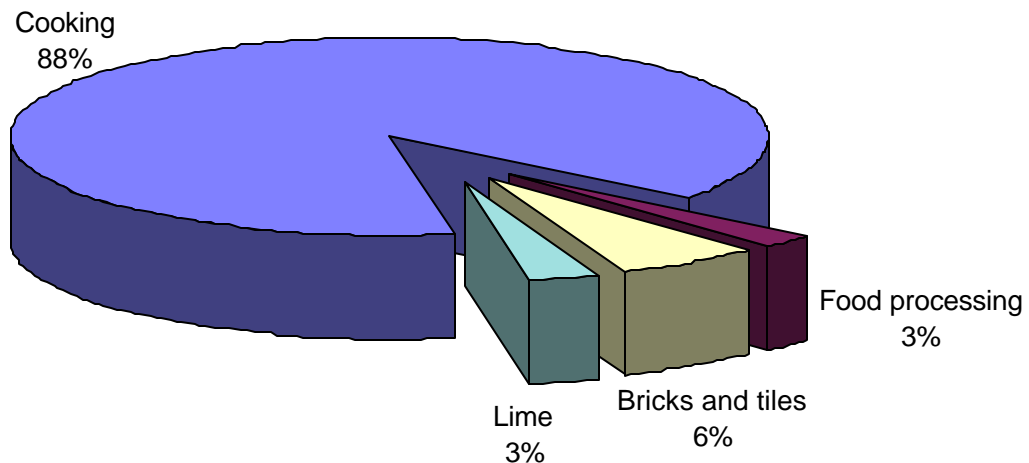
Fig.7.2. Woody biomass consumption by end use, 1986

Of the many annual and perennial crops that are grown in Indonesia, a number have waste products with significant energy potential. These are listed in Table 7.6.

Table 7.6 Perennial crops and plantations with wastes with energy value

Crop	Wastes with energy value
Estate crops	
Rubber	Wood
Oil palm	Stalk, fiber, shell
Coconut	Husk, shell
Tea	Stem
Kina	Wood
Coffee	Stems, shade, trees
Sugarcane	Bagasse
Agricultural residues	
Rice	Husk, straw
Maize	Corn base, stalk
Cassava	Sticks
Groundnut	Shell
Sunflower	Stalk, cob

Source: Regional Energy Development Project of West Java, REDEP Phase II, Vol. I, January 1988

7.6. Features of the wood marketing system

A survey was carried out in rural Gunung Kidul, Central Java in 1988 to analyze the wood marketing system. It was found that wood trading middlemen own larger farms than other households. Wood trading is a specialized occupation, e.g., 60% of all the assembling middlemen surveyed sold nothing but wood, the remainder also traded non-wood agricultural products or non agricultural produce. For about 55% of such assemblers, wood products provided most of their trading profits. Almost all wood trading assemblers (88%) handled fuelwood as their major product, the remaining 12% merely traded charcoal.

The urban market sellers rely mainly on wood selling, some 31% also have non wood products in their assortment. Of the urban market traders, about 23% sell only fuelwood, another 23% sell only charcoal.

The fuelwood is marketed either bundled in faggots or loose per stacked meter. The faggots are handled in a variety of dimensions from the smaller 'unting' of several sticks (worth Rp.20) to voluminous 'bongkok' (worth Rp.1,250). While the variation in size of faggots is great throughout the area, there seems to be some degree of standardization regionally.

In the parts of Gunung Kidul where soils are limy, many lime-kilns are being operated and large quantities of fuelwood are required. It is a common practice in Gunung Kidul that these lime kilns send out their own trucks to collect fuelwood. Thus, in areas where local demand is dominated by such industries, middlemen operate to gather enough fuelwood to fill a truckload. For such bulky transactions bundling is unnecessary. In cases where supply is directed to meet the urban consumption, the wood is perfectly bundled for easier handling and to enable smaller transactions.

Charcoal trade is not common in the area of survey. Reasons attributed to this are scarcity of supply and the fact that more working capital is required with a lower rate of return.

Further, the study showed that the farmers' fuelwood was mainly delivered to local assemblers and local assembly markets, another share was sold directly to local industries.

7.7. Urban Energy Consumption Pattern

Annual energy consumption for the household sector in Indonesia in 1984 represented about 53% of the total national energy consumption. The urban component represents 17.3% of the total household demand.

Table 7.7 Urban energy consumption by fuel type (in %)

Fuel	Low income <Rp.20,000	Middle income Rp 20-40,000	High income >40,000	All income groups
Electricity	6.5	11.6	17.7	11.3
Kerosene	80.0	82.2	63.6	76.6
LPG	0.5	2.3	14.2	4.6
Charcoal	5.0	2.0	1.8	3.1
Wood	8.0	1.7	2.5	4.2
City Gas	0.0	0.2	0.3	0.2
Total	100.0	100.0	100.0	100.0

Source: Energy Planning for Development (Phase II), Appendix 5: Survey of Energy Use in Urban Households, ROI/EDI/IDEA, (1985)

Kerosene represents approximately 77% of the urban household fuel consumption. Cooking is the major end use, accounting for 85% of the average fuel demand per household. Lighting is the other major end use accounting for 10% of the average energy budget.

Table 7.8 End use fuel consumption pattern in households (%)

End use	All income groups	Low income <Rp.20,000	Middle income Rp 20-40,000	High income >Rp 40,000
Cooking				
Kerosene	85.7	85.0	92.6	76.4
LPG	5.5	0.6	2.7	17.9
Wood	4.9	8.3	2.2	3.0
Charcoal	3.6	5.6	2.2	2.2
City Gas	0.3	-	0.3	0.5
Lighting				
Electricity	61.0	46.4	61.4	75.8
Kerosene	39.0	53.6	38.6	24.2

Source: Energy Planning for Development (Phase II), Appendix 5: Survey of Energy Use in Urban Households, ROI/EDI/IDEA, (1985)

8. Lao PDR

8.1. The Country

Lao People's Democratic Republic has an area of 23.68 Mha extending 1,162 km SSE to NNW and 478 km ENE to WSW. Its boundaries are shared by Vietnam in the east, China in the north, Myanmar in the north west, Thailand in the west and Cambodia in the south.

Laos is topographically divided into the northern mountains, comprising 40 per cent of the country and the southern panhandle. The Mekong river is the lifeline of Laos. It is the major transportation artery and the major source of irrigation. Also it supplies fish, a staple of the diet.

8.2. Population and Land Use

The population was 4.17 million according to a mid-1990 estimate, with a density of 18 inhabitants per square kilometer. Assuming an average population growth of 2.9%, the population is expected to reach 5.3 million by 2000. More than 60% of the people live in the valleys of the Mekong river and its tributaries, concentrated in the provinces of Vientianne, Savannakhet, Champasak, Luang Prabang and Khammouane. Elsewhere the population is thinly spread. The nationwide population density is 19 per km^2. Eighty five percent of the population is classified as rural and there is no significant urban-rural migration.

Table 8.1 Land use and population data

	Unit	1987	1988	1989	1990	1991	1992	1993
Total land	'000 ha	23,080	23,080	23,080	23,080	23,080	23,080	23,080
Arable + permanent crop	'000 ha	850	850	849	830	810	805	805
Irrigated land	'000 ha	120	120	120	122	122	125	125
Forest + woodland	'000 ha	12,770	12,690	12,612	12,560	12,520	12,500	12,500
Total population	'000	3,818	3,942	4,071	4,202	4,334	4,469	4,605
Agricultural population	'000	2,781	2,855	2,930	3,006	3,082	3,157	3,232
Fuelwood production*	'000m³	3,527	3,645	3,760	3,883	4,008	4,133	4,254

Source: Country Tables, FAO, Rome (1995)   * Includes wood converted to charcoal*

In a recent study using remote sensing, the land cover types of Laos have been identified and measured. The results of this study for the year 1992-93 are given in Table 8.2.

Table 8.2 Land cover type and aerial coverage of Lao PDR 1992-93

Land cover category	Area (km^2)	%
Moist mixed deciduous	69,204	35.2
Dry mixed deciduous	75,540	38.4
Savanna	1,192	0.6
Scrubland	39,077	19.9
Woody/shrubby vegetation	1,455	0.7
Agricultural	8,945	4.6
Water bodies	722	0.4
No data available	479	0.2
Total	196,614	100.0

Source: Land Cover Assessment and Monitoring - Lao PDR, UNEP Environment Assessment Programme for Asia and Pacific (1995)

8.3. Economy

Laos has a centrally planned economy. The production structure has a predominant agricultural sector which accounts for 61% of GDP and provides 80% of the total employment. The industrial sector contributes only 14% of the GDP. The average growth of industrial production between the period of 1984 to 1989 is 6% per year. Laos belongs to the group of 49 low income countries and is one of the 29 least developed countries in the world. It is also one of the 45 countries considered by UN as most seriously affected (MSA) by recent adverse economic conditions.

Table 8.3 Main economic indicators (1985-1993)

Economic indicators	1985	1986	1987	1988	1989	1990	1991	1992	1993
GDP (const. 1987 US$)	1,053	1,104	1,087	1,065	1,216	1,303	1,350	1,444	1,529
GDP (current US$)	2,368	1,776	1,087	599	732	868	1,028	1,185	1,334
GDP growth (%/y)	5.1	4.8	-1.5	-2.1	14.3	7.1	3.6	7.0	5.9
GNI/capita (1987 US$)	290	300	280	270	300	310	310	320	330
GNI growth (%/y)	4.8	5.1	-1.8	-2.1	13.8	6.2	4.2	6.7	6.5
GNP/capita US$	-	-	-	-	220	200	220	250	280

Source: World Tables, World Bank (1995)

8.4. Energy Situation

In Lao PDR, fuelwood and electricity are produced locally, petroleum products are being imported. Indigenous fuelwood is the main source of energy. The annual fuelwood consumption is estimated to be about 1 m^3 per inhabitant. Both rural and urban households require this mainly for cooking and lighting. Since most of the provinces are not electrified, surplus electricity is exported to Thailand.

Households form the major energy consuming sector in Laos with about 87 to 90% of the total energy consumption, followed by the transport sector. Laos has only a rudimentary industrial sector employing 6% of the work force and contributing only 5% to the GDP. This fact is reflected in its share of energy consumption.

Table 8.4 Total energy consumption by sectors (ktoe)

Year	Household	Commercial	Transport	Industry/agriculture	Total
1987	734	5	67	9	815
1988	758	6	69	9	842
1989	778	6	106	19	909
1990	803	6	100	18	927

Source: Sectoral Energy Demand in Lao PDR, REDP, United Nations (1992)

Fuelwood and charcoal production and consumption are still increasing as is clear from Figure 8.1. Import and export of woodfuels are both negligible.

An increased demand for petroleum products necessitated increased import of these products from 63 ktoe in 1980 to 85 ktoe in 1991.

Table 16.3 Primary energy production and consumption, 1989-1992

Primary energy production	Unit	1989	1990	1991	1992
Solid fuels	ktoe	1	1	1	1
Liquid fuels	ktoe	-	-	-	-
Gaseous fuels	ktoe	-	-	-	-
Electricity	ktoe	57	71	76	75
Total conventional production	ktoe	58	72	77	76
Total consumption	ktoe	96	98	106	114
Per capita consumption	kgoe/capita	24	23	24	26
Fuelwood production	'000 m^3	3,760	3,883	4,008	4,133
	ktoe*	861	889	918	946

*Converted using 1 m^3 wood = 0.23 toe.

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

9. MALAYSIA

9.1. The Country

West and East Malaysia are separated by the South China Sea over a distance of 400 miles. East Malaysia occupies the northern quarter of the island of Borneo. West Malaysia consists of 11 states. The greatest distance in East Malaysia from north to south is 1,126 km and from east to west is 241 km. West Malaysia has a coastline of 1,931 km and East Malaysia 1,558 km. Malaysia has a land boundary with Thailand (576 km), with Brunei (553 km) and with Indonesia's Kalimantan (1,496 km).

West Malaysia has a range of steep forest covered mountains running north-south along the center of the peninsula, flanked on the east and the west by coastal plains. The western coastal lowland is 16 to 80 km wide and the eastern coastal lowland more irregular and less densely populated is 8 to 64 km in width.

9.2. Population and Land Use

The 1993 population of Malaysia was estimated at 19.2 million on the basis of a census held in 1980 when the population was 13.1 million. The population is expected to reach 20.7 million in 2000. West Malaysia contains 85% of the population with 40% of the land area. Three fourths of the population is concentrated in the western portion of the Malay peninsula. On a national scale the density of population is 47 per km^2 rising to 320 per km^2 of arable land. The annual rate of population growth is 2.3%.

Table 9.1 Population and land use data

	Unit	1987	1988	1989	1990	1991	1992	1993
Total population	'000	16,541	16,987	17,439	17,891	18,344	18,796	19,247
Agricultural population	'000	5,453	5,445	5,433	5,417	5,399	5,377	5,349
Total land	'000 ha	32,855	32,855	32,855	32,855	32,855	32,855	32,855
Arable + permanent crop	'000 ha	4,880	4,880	4,880	4,880	4,880	4,880	4,880
Irrigated land	'000 ha	334	334	335	335	340	340	340
Forest + woodland	'000 ha	19,670	19,455	19,472	19,406	19,385	19,352	22,304
Fuelwood production*	'000m³	8,062	8,280	8,499	8,719	8,938	9,157	9,375

Source: Country Tables, FAO, Rome (1995)   ** Includes wood converted to charcoal*

The urban and rural population in Malaysia as per the national census in 1991 are 50.6 and 49.4%, respectively and the average household size was estimated to be 4.9 in 1988.

About 67.9% of the total land area of Malaysia is classified as forests and woodlands. Permanent crop land and arable lands constitute 14.6%, and the irrigated land area makes up only 1% of the total land area.

9.3. Economy

Malaysia is one of the most impressive economies in Asia after Japan and Singapore. The economy is export based and is therefore largely affected by changes in world prices of raw materials such as rubber, palm oil and tin. It is one of the upper middle income countries of the

world with a free market economy with a predominant private sector. Nearly 3.5% of the national income is received by the lower 20% of the people and 40% of the national income is received by the top 10%.

Table 9.2 Main economic indicators

Economic indicators	1985	1986	1987	1988	1989	1990	1991	1992	1993
GDP (const. 1987 million US$)	29,645	29,986	31,602	34,427	37,597	41,256	44,827	48,326	52,417
GDP (current million US$)	31,200	27,735	31,602	34,696	37,872	42,822	47,111	58,014	64,450
GDP growth (%/year)	-1.1	1.2	5.4	8.9	9.2	9.7	8.7	7.8	8.5
GNI/capita (1987 US$)	1,840	1,670	1,810	1,960	2,080	2,260	2,380	2,570	2,760
GNI growth (%/year)	-3.8	-7.0	11.0	11.4	8.7	11.2	8.7	10.2	9.9
GNP/capita (US$)	1,910	1,880	1,960	2,130	2,240	2,400	2,540	2,830	3,140

Source: World Tables, World Bank (1995)

9.4. Energy Situation

Little information is available about the production and consumption of energy in Malaysia. Table 9.3. shows these data for the period 1989-92.

Table 9.3 Energy production and consumption data

Primary energy production	Unit	1989	1990	1991	1992
Solid fuels	ktoe	80	73	126	133
Liquid fuels	ktoe	28,774	30,403	31,115	31,675
Gaseous fuels	ktoe	11,805	11,999	14,948	18,700
Electricity	ktoe	450	343	383	437
Total conventional production	ktoe	41,109	42,818	46,572	50,946
Total consumption	ktoe	16,230	18,661	19,693	23,689
Per capita consumption	kgoe/capita	931	1,043	1,074	1,261
Fuelwood production	'000 m^3	8,499	8,719	8,938	9,157
	ktoe*	1,946	1,996	2,047	2,097

* A conversion factor of 1m^3 = 0.23 toe is used.

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

According to the energy balance of 1992 prepared by AEEMTRC, the total consumption of energy in Malaysia is about 17,456 ktoe, of which petroleum products constitute 11,362 ktoe (65%). Coal and natural gas consumption are about 672 and 1,368 ktoe respectively.
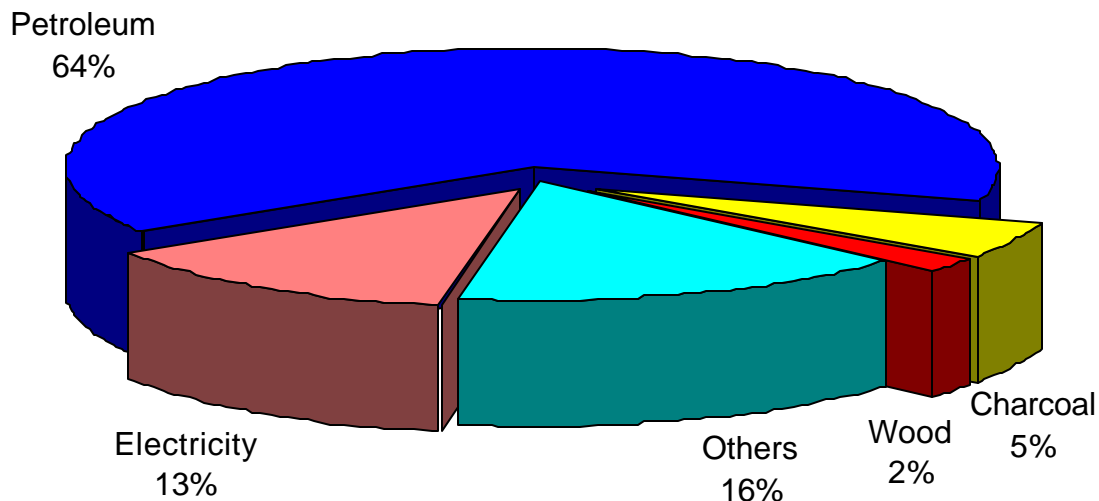
Fig 9.1 Share of fuel types in the energy balance, 1992 (AEEMTRC, 1994)

Most of the traditional fuels are used in the domestic sector for cooking. Yet, there is a lack of literature on utilization of traditional fuels. According to a few surveys carried out in the late 70's and early 80's, about 47 to 59% of rural households use fuelwood for cooking and 8 to 10% use charcoal. In the urban areas only 9% of households use fuelwood for cooking but 27% use charcoal. LPG and kerosene are the major cooking fuels in the urban areas. Table 9.4 gives the total production and trade statistics of fuelwood and charcoal in Malaysia for the period 1985-93. Figures for fuelwood production differ from the ones given in table 9.1 and 9.3, which may be due to the fact that the latter include wood for charcoal.

Table 9.4 Total production and trade of woodfuel and charcoal

| Year | Fuelwood ('000 m^3) | Charcoal ('000 MT) | | |
	Production	Production	Import	Export
1985	5,537	351	61	19
1986	5,687	360	52	13
1987	5,842	370	47	13
1988	6,000	380	47	13
1989	6,159	390	47	13
1990	6,319	400	47	13
1991	6,478	410	15	21
1992	6,637	420	15	28
1993	6,795	430	9	18

Source: FAO Forest Products Yearbook 1982 - 1993, FAO Forestry Series No. 28, FAO, Rome (1993)

9.5. Residential Sector

In Malaysia, energy in the residential sector is mainly used for cooking, lighting, water heating, air conditioning and the operation of household appliances. The major household energy used is electricity. Other fuels such as kerosene, LPG, charcoal and fuelwood are used mainly for cooking. From a baseline study, it was found that 85% of the urban households used electricity and 36 and 24 percent consumed LPG and kerosene, respectively. 7 to 39 percent of the urban households used charcoal, 1% to 10% firewood.

Table 9.5 Final energy end use in the household sector in 1983 (TJ)

Fuels	Cooking	Hot water	Air. cond	Lighting	El. appliances	Total
LPG	4,998	25	0	0	0	5,024
Natural Gas	644	0	0	0	0	644
Kerosene	12,526	0	0	800	0	13,326
Charcoal	1,430	0	0	0	0	1,430
Traditional fuels	20,000	0	0	0	0	20,000
Electricity	638	80	838	1770	4,649	7,975
Total	40,236	105	838	2,570	4,649	48,398

Source: Sectoral Energy Demand in Malaysia, UNESCO/REDP, Bangkok (1989)

10. MALDIVES

10.1. The Country

The Republic of Maldives is an archipelago of about 1,200 coral islands, spread over an area of 3.00 Mha in the north-central Indian Ocean, about 650 km. South West of Southern India and Sri Lanka. This island chain stretches 820 km. north to south and about 120 km. east to west with a total land area of 298 km^2 or 0.3 Mha The islands are formed in to 26 natural clusters called atolls and for administrative purposes they are grouped into 19 atolls.

Table 10.1 Land use and population

	Unit	1987	1988	1989	1990	1991	1992	1993
Total land	'000 ha	30	30	30	30	30	30	30
Arable + perm. crop land	'000 ha	3	3	3	3	3	3	3
Forests + woodland	'000 ha	1	1	1	1	1	1	1
Total population	'000	196	202	209	216	223	231	238
Agricultural population	'000	128	131	135	138	142	146	150

Source: Country Tables, FAO, Rome (1995)

10.2. Population and Land Use

The population of Maldives was estimated in 1985 to be 178,000 on the basis of an official census held in 1977 when the population was 142,832. The population is expected to reach 300,000 by 2000 assuming an annual growth rate of 2.8% and a birthrate of 43 per 1,000 per year. Only 202 of the 1,200 islands are inhabited and the population is unevenly distributed with over 60,000 people living on an area of 1.85 km^2 in the capital Male. The urban population constitutes 25.9% of the total population. There are only 25 islands with more than 1,000 people with a density of 597 per km^2. The average household size is 6.1. As per FAO (1995), the mid 1993 population of Maldives was 200,000.

10.3. Economy

The Maldives has a free market economy with a predominant private sector. It is one of the 49 low-income countries of the world and considered one of the 29 least developed by the UN.

Table 10.2 Principal economic indicators

GNP (1982, US$ Million)	74
GNP annual growth rate (1983)	10%
GNP/capita (1982, US$)	415
GDP (1984, Million Rf)	537
GDP/capita (1984, Rf)	3,158

Source: Encyclopedia of the Third World, Kurian, G.T.,Third Edition, Volume III, England, 1986

As of 1985, no national account system or integrated development planning exists, except for a series of projects targeted on improvement of fisheries and related industries, food processing, communications, tourism and health services.

10.4. Energy Situation

Conventional energy has contributed considerably to the rapid development of the economy. Large volumes of petroleum products are required in areas such as mechanization programs in fishing and transport, tourism industry, airport operations, construction, manufacturing, domestic cooking and electricity production.

Table 10.3 Pattern of conventional energy consumption

	1989	1990	1991	1992
kgce/capita	140	150	145	145
ktoe	29	32	32	33

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

Woodfuel is the only indigenous and most important source of energy in Maldives. It is primarily used in the residential sector for cooking food and for the preparation of food ingredients. A small amount of fuelwood is also used in the fish processing, palm sugar making and lime making industries.

Based on the 1980/81 Household Income and Expenditure survey, fuelwood consumption in 1984 was estimated to be 75,757 tons or 22,700 toe. The per capita fuelwood consumption is 437 kg for Maldives as a whole or 172 kg per capita in Male and 519 kg per capita for the rest of the country. But this is considered to be low by another study carried out by the Intermediate Technology Development Group in 1988, which gives a figure of 350-584 kg per capita when food preparation only is considered and 1,460-2,445 per capita when food processing is also taken into account.

Fuelwood supply in Male is commercialized and the unit of measurement is a bundle. The price of a bundle increased from 1.50 Rf. in 1976 to 5.00 in 1987. Table 10.4 shows the increasing fuelwood demand from 1985 to 1988.

Table 10.4 Pattern of woodfuel consumption, 1985-88

Unit	1985	1986	1987	1988
ton	78,698	81,510	84,324	87,135
toe*	23,609	24,453	25,297	26,140

Assuming 1 ton of wood equals 0.3 tons of oil

Source: Sectoral Energy Demand in Maldives, Regional Energy Development Programme, United Nations, Bangkok (1992)

Fuelwood shortage is felt in Male and other overcrowded islands such as Naifaru-Lhariyani Atoll. The local supplies have long been exhausted and demand is now being met through collection from uninhabited islands. This has created opportunities for boat owners, and many small businesses have been established to supply wood to crowded islands.

11. MYANMAR

11.1. The Country

Myanmar has a total area of 67.85 Mha, of which 8.1 Mha is under cultivation, 1.9 Mha fallow land, 9.7 Mha cultivable waste land and 9.7 Mha reserved forests.

11.2. Population and Land Use

The population of Myanmar was estimated to be 41.8 million in 1990 growing at a rate of 1.9% per year. About 76% of all inhabitants live in the rural areas of the country. It is also estimated that the rural population of this country is growing at the rate of 1.8% per year whereas the urban population is growing at the rate of 2.1% per year. Of the total rural population of 30.9 million, 4.4 million households are families engaged in farming with an average family size of 5 members per family making a total of 21.9 million or 71% of the rural population depending on agriculture. The remaining population is either directly or indirectly related to farming.

Table 11.1. Population and land use data

	Unit	1987	1988	1989	1990	1991	1992	1993
Population	'000	39,187	40,043	40,919	41,813	42,724	43,652	44,596
Agricultural	'000	19,040	19,226	19,414	19,600	19,783	19,962	20,136
Total land	'000 ha	65,754	65,747	65,761	65,755	65,755	65,755	65,755
Arable + permanent crop	'000 ha	10,060	10,011	10,034	10,069	10,057	10,039	10,087
Irrigated land	'000 ha	1,079	997	1,018	1,005	1,003	998	1,068
Forest + woodland	'000 ha	32,385	32,384	32,418	32,399	32,397	32,387	32,408
Fuelwood production*	'000 m^3	16,722	17,089	17,463	17,846	18,236	18,752	19,156

Source: Country Tables, FAO, Rome (1995)   **Includes wood converted to charcoal*

As per Table 11.1, about 49% of the total land area in under forest cover and 15% is under permanent crop. About 1.6% of the land area is irrigated. As per FAO (1993), the details of the forest cover of Myanmar can be represented as follows:
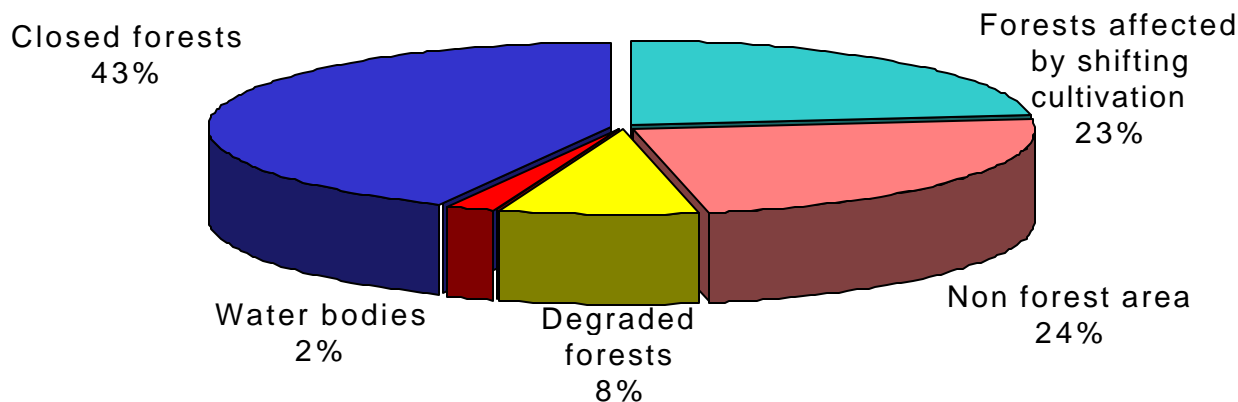
Fig 11.1 Forest and land use in Myanmar (FAO, 1993)

The extent of the different land cover categories of Myanmar has been estimated by means of remote sensing for the years 1985-86 and 1992-93. As shown in Table 11.2, there is a clear tendency towards degradation of land cover and deforestation.

Table 11. 2. The extent of different land cover types in Myanmar

Land cover category	1985-86		1992-93	
	Area (km^2)	%	Area (km^2)	%
Evergreen forest	232,212	35.1	203,246	30.8
Deciduous forest	95,931	14.5	84,955	12.9
Mangrove forest	1,827	0.3	1,824	0.3
Scrubland	193,816	29.3	220,676	33.4
Agriculture	114,052	17.3	138,252	20.9
Water bodies	1,676	0.3	1,036	0.2
No data available	21,408	3.2	10,908	1.7
Total	660,921	100.0	660,898	100.0

Source: Land Cover Assessment and Monitoring - Myanmar, Volume 5-A, UNEP Environment Assessment Program for Asia and the Pacific, Bangkok (1995)

11.3. Economy

Myanmar is a centrally planned, state owned economy. The economic growth rate between 1962 and 1988 averaged 2.2%, just keeping pace with the population growth. The economy of Myanmar is very much dependent on the rural production of goods - agriculture, livestock, fishery and forestry. In 1989/90, goods production accounted for 62% of GDP. Of this, agriculture accounted for 41%; livestock and fishery 7% and forestry 2% i.e. 50% of GDP and 80% of total goods production. Even though the industrial sector accounts for 9% of GDP, a good portion of these industries is dispersed in the rural areas. The contribution of the rural economy to the composition of GDP is very high and thus very important in Myanmar's economy.

Table 11.3. Net output of different sectors of Myanmar

	1985-86 (MUS$)	(%)	1987-88 (MUS$)	(%)	1988-89 (MUS$)	(%)	1990-91 (MUS$)	(%)
Goods	**5470**	**61.3**	**5154**	**60.8**	**4466**	**59.4**	**5064**	**61.6**
Agriculture	3548	39.7	3334	39.3	2893	38.5	3227	39.3
Livestock and fishery	635	7.1	674	7.9	603	8.0	595	7.2
Forestry	121	1.4	110	1.3	108	1.4	162	2.0
Mining	85	1.0	69	0.8	55	0.7	69	0.8
Process and manufacturing	887	9.9	777	9.2	653	8.7	741	9.0
Power	44	0.5	48	0.6	45	0.6	56	0.7
Construction	151	1.7	143	1.7	110	1.5	215	2.6
Services	**1324**	**14.8**	**1414**	**16.7**	**1368**	**18.2**	**1284**	**15.6**
Transportation	321	3.6	325	3.8	268	3.6	303	3.7
Communication	33	0.4	47	0.6	50	0.7	50	0.6
Financial institutions	213	2.4	239	2.8	256	3.4	41	0.5
Social and administrative	410	4.6	438	5.2	444	5.9	523	6.4
Rental and services	348	3.9	366	4.3	351	4.7	367	4.5
Trade	**2135**	**23.9**	**1913**	**22.6**	**1684**	**22.4**	**1872**	**22.8**
Total net output	**8929**	**100.0**	**8481**	**100.0**	**7518**	**100.0**	**8220**	**100.0**

Source: Assessment of Rural Energy Use and Potential in Myanmar, Thi Thi Aye, Asian Institute of Technology, Bangkok (1995)

11.4. Energy Situation

Myanmar is endowed with abundant and varied indigenous sources of energy including hydropower, natural gas, crude oil, biomass, and coal. Since Myanmar's centrally planned economy has not encouraged private sector and external participation, the conventional energy consumption is still low. It was estimated that in 1988/89, 79.5% of the total energy consumption was from biomass resources. The trend of conventional energy and fuelwood production and consumption can be understood from Table 11.4.

Table 11.4. Conventional energy production and consumption data

Primary energy production	Unit	1989	1990	1991	1992
Solid fuels	ktoe	37	32	33	32
Liquid fuels	ktoe	890	826	701	751
Gaseous fuels	ktoe	1,007	1,002	930	906
Electricity	ktoe	98	107	109	110
Total conventional production	ktoe	2,032	1,967	1,773	1,799
Total consumption	ktoe	1,740	1,727	1,639	1,606
Per capita consumption	kgoe/capita	43	41	38	37
Fuelwood production	'000 m^3	17,463	17,846	18,236	18,632
	ktoe*	3,999	4,086	4,176	4,266

*assuming 1 m^3 wood = 0.23 toe

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

Information on the share of production of various fuels in Myanmar is shown in Table 11.5.
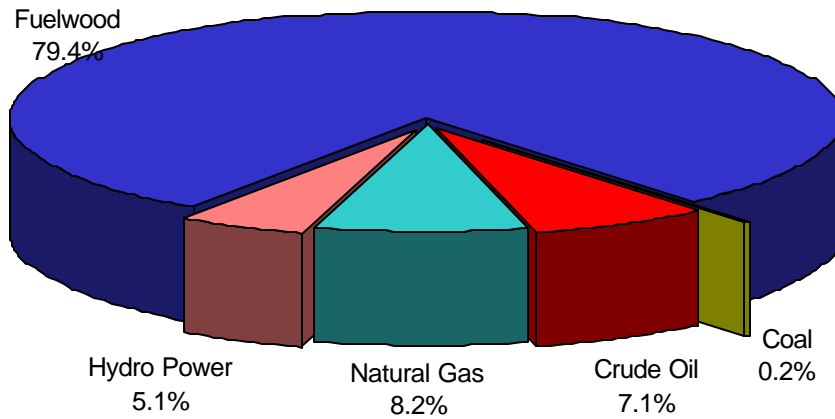
Fig 11.2 Production of various fuels in 1990 (REDP, 1992)

Table 11.5. Primary energy mix (%) 1985-90

Energy source	1985	1986	1987	1988	1989	1990
Coal	0.3	0.3	0.3	0.2	0.3	0.2
Crude oil	10.6	9.0	7.5	6.2	7.0	7.1
Natural gas	8.8	9.9	10.3	9.9	9.7	8.2
Hydropower	4.2	4.5	4.4	4.0	4.7	5.1
Fuelwood	76.1	76.3	77.5	79.7	78.3	79.4
Total	100.0	100.0	100.0	100.0	100.0	100.0

Source: Sectoral Energy Demand in Myanmar, Regional Energy Development Programme, United Nations, Bangkok (1992)

As in many other developing countries in the world, biomass is the major source of energy in both the domestic and industrial sectors. In Myanmar fuelwood and charcoal supply 84% of the final consumption. The remaining 16% consists of conventional sources of energy such as oil, gas and electricity.
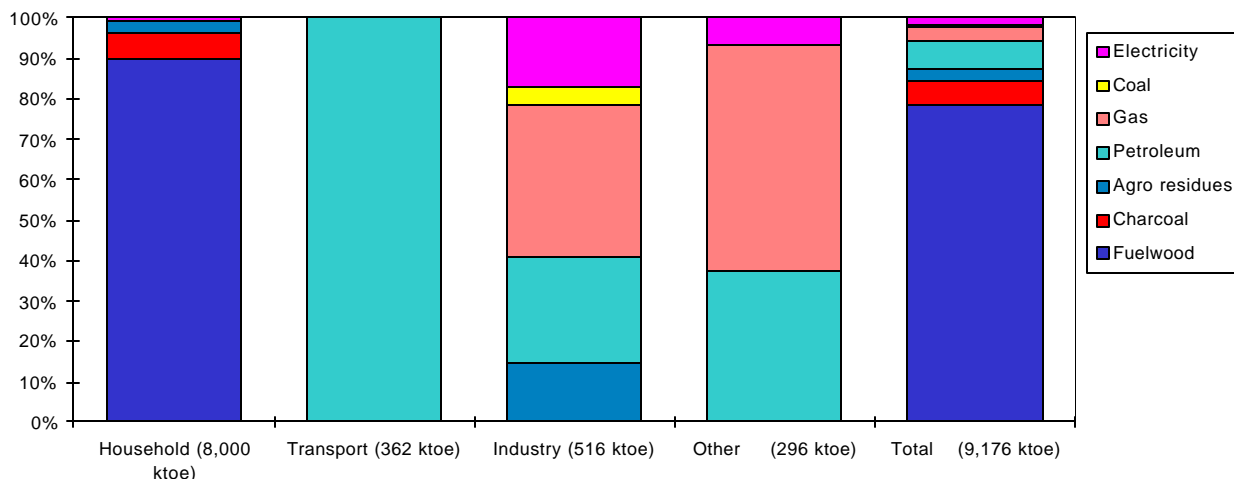
Figure 11.3 Sectoral energy consumption (WB, 1991)

Table 11.6. Final energy consumption by sector in 1990 (ktoe)

Fuel	Household	Transport	Industry	Other	Total	%
Fuelwood	7,181.5				7,181.5	78.3%
Charcoal	535.6				535.6	5.8%
Agr. residues	227.8		75.9		303.7	3.3%
Petroleum	7.3	362.5	134	109.8	613.6	6.7%
Gas			194.6	167.1	361.7	3.9%
Coal			23.6		23.6	0.3%
Electricity	48.3		88.1	19.5	155.9	1.7%
Total	8,000.5	362.5	516.2	296.4	9,175.6	100.0%
In %	87.2%	4%	5.6%	3.2%	100.0%	

Source: UNDP Sixth Country Programme Union of Myanmar, Programme Sectoral Review of Energy; Report Prepared by John Sousing, et. al., World Bank (1991)

11.5. Rural Energy Consumption Pattern

A survey had been carried out in 1995, to find out the energy consumption pattern in the rural areas of Myanmar. Single representative villages were selected on the basis of population, number of households and infrastructure development from three different regions of the country: the dry zone, the coastal region and the hilly region. 25 households were selected from these villages based on income levels. The survey showed that rural households use various fuels such as fuelwood, charcoal, rice husk, kerosene, and diesel oil. Fuelwood plays an important role in household cooking and also small village industries. The share of fuelwood consumption is about 70% of the total energy consumption. Charcoal and kerosene rank second and third with 8.2% and 7.9% of the total energy consumption.
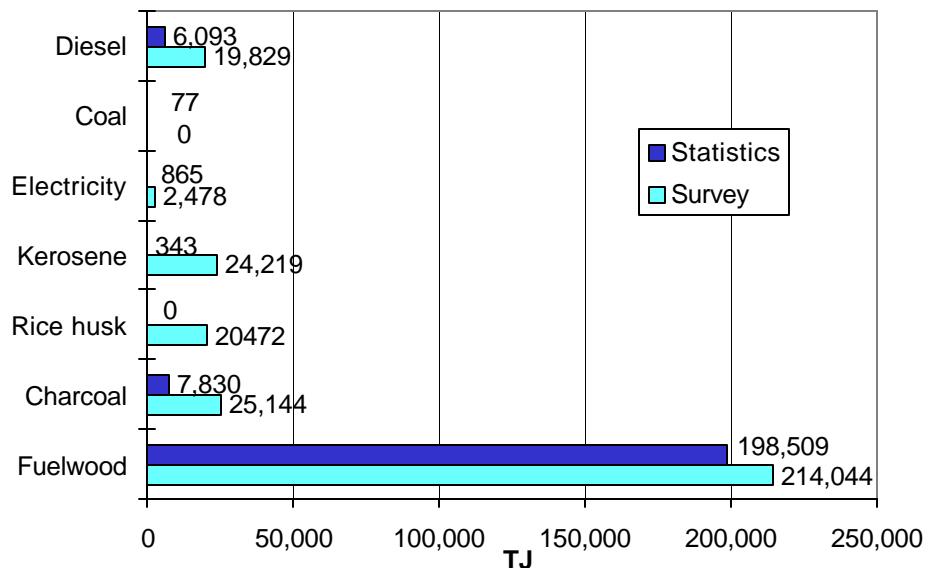
Fig 11.4. Fuel consumption as established by survey and statistics (Aye, 1995)

Three major household end uses are cooking, lighting and space heating. In fact, more than 90% of the household energy is consumed for cooking. Kerosene is used mainly for lighting, the second major energy consuming activity. Space heating uses fuelwood only.

The 1995 prices for different energy sources are shown in Table 11.7. It is found that the choice of household fuel is determined by its price, the efficiency of the end use devices and the convenience of use as well as willingness to pay for the fuel. Even though the pricing structure makes kerosene, LPG and electricity the preferred fuels, these are not readily available to all consumers.

Table 11.7. Prices of different energy sources

Energy source	Unit	Market Price	Retail Price	Economic value
Fuelwood	Ks/kg	2.60	2.60	N.A.
Charcoal	Ks/kg	5.30	5.30	5.30
Rice husk	Ks/kg	1.50	1.50	1.50
Candle	Ks/kg	1.10	1.10	1.10
Electricity	Ks/kWh	2.50	2.50	N.A.
Kerosene	Ks/gallon	179.80	-	179.80
Diesel	Ks/gallon	160.00	-	110.00

Source: Assessment of Rural Energy Use and Potential in Myanmar, Thi Thi Aye, Asian Institute of Technology, Bangkok (1995)

The prices indicated in Table 11.7 for the petroleum products are the official prices at which state economic enterprises sell to the public.

Fuelwood production in Myanmar is carried out by the private sector. In a large part of rural Myanmar, fuelwood is available free of cost. The price of 2.57 ks/kg of fuelwood mentioned here is the observed average price prevailing in and around the survey area. It is to be noted that in a large part of rural Myanmar, fuelwood is obtained at zero cost.

Table 11.8. Fuelwood production and the costs involved

Item	kyats/air dried ton
Cutting & carrying of wood	105
Processing losses	30
Loading	20
Transport by ship	240 per mile
Transport by road	140 per mile
Unloading	30

Source: Assessment of Rural Energy Use and Potential in Myanmar, Thi
Thi Aye, Asian Institute of Technology, Bangkok (1995)

In Myanmar charcoal production is also handled by the private sector. The cost of charcoal production and related activities are given in Table 11.9.

Table 11.9. Charcoal production and the costs involved

Item	Cost (kyats/air dried ton)
Cutting and transport of wood	100-110
Loading kiln	10
Firing and watching	10
Unloading	120
Kiln license	6
Cost of bag	340
Transport to packer	0.5 per km
Packing in basket/bag*	37
Transport by ship	1.5 per km
Transport by load	4.7 per km
Local transport	370

*Baskets varied in size from 12 to 24 kg, bags were either 27 or 41 kg.

Source: Assessment of Rural Energy Use and Potential in Myanmar, Thi Thi Aye, Asian Institute of Technology, Bangkok (1995)

11.6. Fuelwood Resources and Reserves

Based on satellite imagery data obtained in 1980, it has been estimated that Myanmar has 48% closed forest area and about 22% forest fallow. In addition to this, about 300 km^2 of tree plantations have existed since 1988. In 1980, the fuelwood supply was in surplus by 27,400 million m^3.

Table 11.11. Plantations established between 1968-88

Category	Area (km^2)	%
Commercial plantations	1,631	57.2
Village supply plantations	751	26.3
Industrial plantations	205	7.2
Catchment protection	265	9.3
Total	2,852	100.0

Source: Union of Myanmar, Status of Rural Energy Supply and Demand (1990)

11.7. Fuelwood Production, Transport and Marketing

For rural households, fuelwood is the principal fuel. It is usually collected on a subsistence basis from nearby forests, although in some cases it may be purchased by villagers. Fuelwood is also the principal fuel for the majority of urban households who purchase it from retail outlets. Transportation distances are usually relatively short.

The usual method of purchase both in rural and urban areas is by bundles or individual pieces. The bundles are about 1 to 2 ft in girth and 1.5 ft long and weigh between 3 and 5 lb. One hundred pieces weigh 90 to 100 lb.

12. NEPAL

12.1. The Country

Nepal has a diverse physical terrain, ranging from the relatively flat and fertile plains of Terai to the rugged landscape of high mountains situated along the southern slopes of the Himalayas. It has a total area of 14.08 Mha out of which 21% is cultivated land, 12% is grassland and 37% is forest land with crown cover exceeding 10%. Another 5% is degraded forest and 18% includes rocks, waterways, and settlements. The remaining 7% consists of non cultivated inclusions adjoining farm lands. Nepal is about 885 km long and 201 km wide. Its total international border of 2,671 km is shared by China (1,078 km) and India (1,593 km). About eighty per cent of Nepal is hilly and mountainous.

Land inventory studies (using remote sensing facilities) conducted on Nepal show the changes in the land cover categories in the period between 1985/86 and 1992/93.

Table 12.1. Land cover types and aerial coverage of Nepal, 1985/86-1992/93

Land cover category	1985-86		1992-93	
	Area (km^2)	(%)	Area (km^2)	(%)
Coniferous	3,736	2.6	2,722	1.8
Hardwood forest	14,923	10.4	20,927	14.6
Hardwood forest (low crown density)	25,488	17.7	17,655	12.3
Mixed forest	4,009	2.8	8,037	5.6
Mixed forest (low crown density)	86	-	4,790	3.3
Agriculture	29,529	20.6	45,135	31.4
Shrub	-	-	2,180	1.5
Grazing	-	-	8,105	5.6
Rock	1,729	1.2	10,300	7.2
Snow	-	-	4,075	2.8
No data available (cloud covered)	64,223	44.7	19,795	13.8
Total	143,723	100.0	143,721	100.0

Source: Land Cover Assessment and Monitoring, Nepal, Volume 6-A, UNEP Environment Assessment Programme for Asia and the Pacific, Bangkok (1995)

12.2. Population and Land Use

The population of Nepal was estimated at 16.9 million in 1985 based on the last official census held in 1981 when the population was 15.0 million. The population is expected to reach 23.7 million by 2000. The annual growth rate is 2.3% for the population as a whole and 5.3% for the urban population. Based on a report by USAID (1989), about 92% of the population lives in rural areas. The population is unevenly distributed with barren highlands virtually uninhabited while Katmandu valley is one of the most densely populated areas of the world. Nepal has an overall population density of 117 inhabitants per km^2, in cultivated areas this is 356 per km^2. The average household size is 5.3 persons.

Table 12.2. Land use and population data, 1987-1993

	Unit	1987	1988	1989	1990	1991	1992	1993
Total population	'000	17,854	18,305	18,770	19,253	19,755	20,276	20,812
Agricultural population	'000	16,444	16,836	17,239	17,657	18,089	18,537	18,997
Total land	'000 ha	13,680	13,680	13,680	13,680	13,680	13,680	13,680
Arable + permanent crop land	'000	2,339	2,339	2,349	2,339	2,353	2,354	2,354
Irrigated land	'000	850	900	943	900	883	850	850
Forest + woodland	'000	5,400	5,390	5,380	5,751	5,750	5,750	5,750
Fuelwood production*	'000 m^3	16,701	17,143	17,596	18,052	18,513	18,971	19,440

Source: Country Tables, FAO, Rome (1995)   ** Includes wood converted to charcoal*

12.3. Economy

Nepal has a free market economy with a predominant private sector. It is one of the 49 low income countries as well as one of the 29 least developed countries. It is considered one of the 45 countries most seriously affected by adverse economic conditions. About 55% of the GDP is contributed by agriculture. Forest products play an important part in the economy of Nepal, contributing some 15% to GDP. About 75% of Nepal's energy needs is met by this sector.

Table 12.3. Major economic indicators

Economic indicators	1985	1986	1987	1988	1989	1990	1991	1992	1993
GDP (1987 US$ mil)	2,784	2,909	2,957	3,185	3,323	3,478	3,696	3,844	3,959
GDP (current US$ millions)	2,621	2,815	2,957	3,487	3,525	3,628	3,864	3,531	3,748
GDP av. annual growth (%/y)	6.1	4.5	1.6	7.7	4.3	4.7	6.3	4.0	3.0
GNP/capita (US$)	160	170	180	200	210	210	210	200	190

Source: World Tables 1995, Published for the World Bank, The Johns Hopkins University Press, Baltimore and London, New York, 1995

12.4. Energy Situation

Hydropower is the major indigenous energy source. However, out of the total theoretical potential of 83,000 MW and economically feasible potential of 42,000 MW the currently installed capacity is only 232 MW.

Table 12.4. Nepal energy balance for 1994-95 (ktoe)

	Fuelwood	Crop residues	Dung	Traditional	Coal	Petro. prod.	Electr-icity	Comm -ercial	Total	share of total
Primary production	4,604.0	1,007.4	542.7	6,154.1			77.9	77.9	6,232.0	93.0%
Import					66.6	463.5	9.3	539.4	539.4	8.0%
Export						-27.7	-3.6	-31.3	-31.3	-0.5%
Stock changes						2.0		2.0	2.0	0.0%
Power generation						-24.2	7.2	-17.0	-17.0	-0.3%
T&D losses							-24.3	-24.3	-24.3	-0.4%
Final supply	4,604.0	1,007.4	542.7	6,154.1	66.6	413.6	66.5	546.7	6,700.8	100.0%
Domestic	4,473.0	998.8	542.7	6,014.5	0.3	107.1	26.1	133.5	6,148.0	91.8%
Industrial	108.0	7.3		115.3	59.2	28.3	27.7	115.2	230.5	3.4%
Commercial	23.0	1.3		24.3	6.7	47.9	9.5	64.1	88.4	1.3%
Transport					0.4	178.4	0.1	178.9	178.9	2.7%
Agricultural						45.7	2.0	47.7	47.7	0.7%
Others							1.0	1.0	1.0	0.0%
Non-energy use						6.2		6.2	6.2	0.1%
Final consumption	4,604	1,007.4	542.7	6,154.1	66.6	413.6	66.5	546.7	6,700.8	100.0%
Share of total	68.7%	15.0%	8.1%	91.8%	1.0%	6.2%	1.0%	8.2%	100.0%	

Source: Water and Energy Commission Secretariat, Katmandu, Nepal (1996)

12.5. Role of Traditional Energy

In 1993/94, fuelwood accounted for 69% of all energy consumed. Fuelwood originates from public forests, shrubs and grasslands and private holdings. Nepal has an estimated 8.85 Mha of potentially productive forests, shrubs and grasslands of which 6.73 Mha are estimated to be forests and scrubland only and about 50% is used for fuelwood collection. Of the estimated total sustainable yield of 17.5 million tons of fuelwood, 6 million tons is accessible. The demand for fuelwood in the country has rapidly expanded due to population growth, and has resulted in tremendous pressure on the existing forests.

Agricultural residues constitute some 14.9% of the energy consumption and about 4% of the long term theoretical indigenous energy potential of Nepal. In 1985/86 total production of crop residue was estimated as 12.5 million tons, of which 67.4% is rice straw. At present most of the agricultural residues are burned in open fires. Dung constituted 8.2% of the energy consumption.
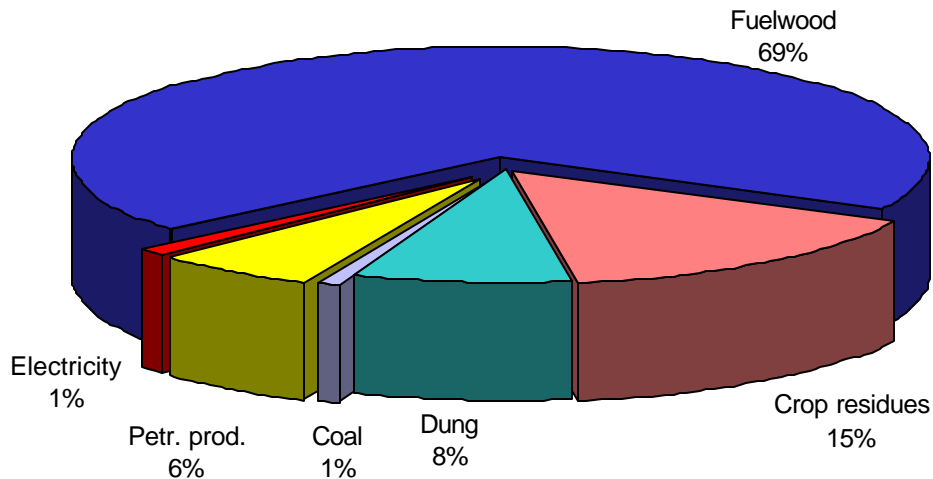
Fig 12.1 Energy demand by fuel type, 1993/94 (WECS, 1996)
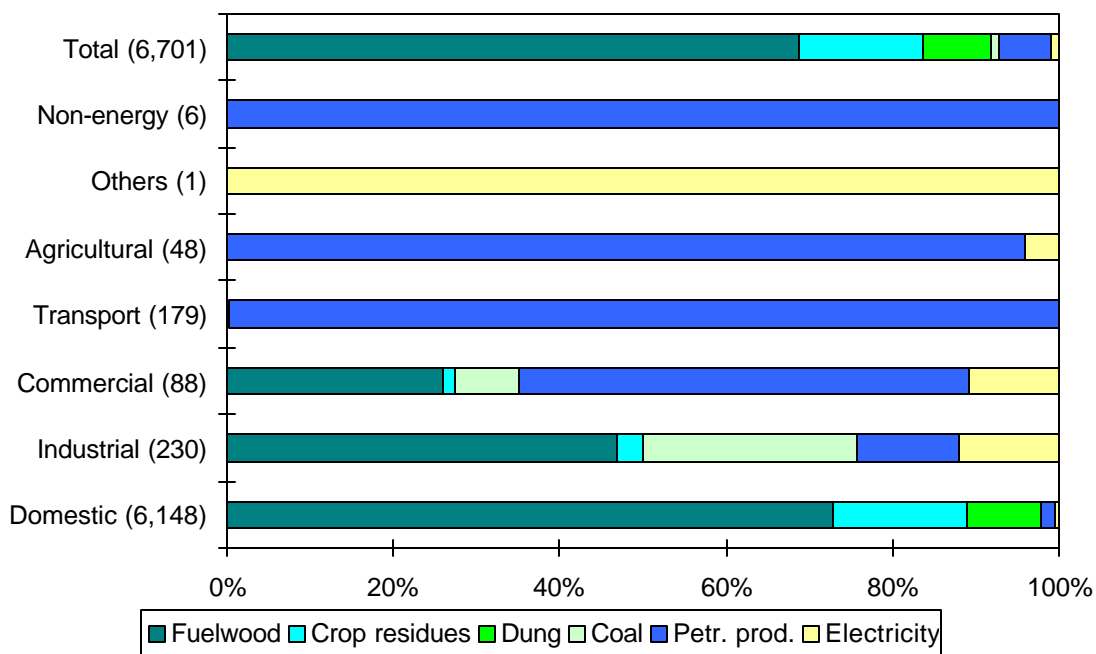
Fig 12.2. Energy demand pattern, 1993/94 (WECS, 1996)

12.6. Sources of Fuelwood

Fuelwood is used for cooking by the majority of the urban households in the Katmandu Valley even though a large proportion of households in Katmandu and Lalitpur use LPG and kerosene for cooking. Fuelwood is extensively used in commerce, industry and institutions such as restaurants, brick and tile factories, hospitals and army barracks. About 95% of the fuelwood supply in Katmandu is from the public forests of the Terai Plains, it is transported by trucks over

a distance of 150 to 300 km. Another 2.5% comes from illegal roadside suppliers also in Terai. An estimated 2.5% of fuelwood supply is brought in by backload from surrounding villages within the valley. In 1988 the total fuelwood flow to the valley was estimated to be 82,500 tons.

Table 12.5. Sources of fuelwood supplies to Katmandu Valley

Source	Quantity (ton)		(%)
Terai public forests		78,100	94.7
NFC supply from public forests	27,000		32.7
Industrial/commercial Permit via NFC	16,000		19.4
Other truckload supplies	35,100		42.6
Illegal roadside supplies		2,000	2.4
Backload supplies from within the valley		2,400	2.9
Total		82,500	100

Source: The Forest Products Marketing Systems in Nepal: Case Study of the Urban Areas of Katmandu Valley, Shaikh, Asif M., United States Agency for International Development, Nepal (1989)

12.7. Energy Consumption Pattern

As is clear from Table 12.4, Nepal very much relies on traditional energy sources, especially in the domestic sector. An estimate of traditional energy demand in the rural and urban areas of Nepal is given in Table 12.6

Table 12.6. Estimate of traditional energy demand in the domestic sector (kton)

Region	Fuelwood		Agricultural residues		Dung	
	Rural	Urban	Rural	Urban	Rural	Urban
Eastern						
Hill	1,457	8	114	0.0	10	0
Terai	2,055	85	656	0.0	562	0
Central						
Hill	1,190	185	366	0.0	14	0
Terai	1,063	61	699	0.0	1,189	0
Western						
Hill	1,729	29	216	0.0	13	0
Terai	794	32	80	0.0	19	0
Mid-West						
Hill	903	6	68	0.0	8	0
Terai	881	13	23	0.0	28	0
Far-West						
Hill	614	3	46	0.0	5	0
Terai	573	29	15	0.0	18	0
Total						
Hill	5,895	232	812	0.0	53	0
Terai	5,368	221	1,475	0.0	1,993	0
Total	11,263	454	2,287	0.0	2,047	0

Source: Sectoral Energy Demand in Nepal for the Year 1990/91, Regional Energy Development Programme, United Nations, Bangkok (1992)

It is interesting to note the estimates of per capita fuelwood demand by APROSC in 1981/82 and USAID in 1986/87. These figures are given in Table 12.7. Both per capita demand and the percentage of households using fuelwood declined by 20% between 1981 and 1986/87. This may be due to the increase in fuelwood prices and the availability of alternative cooking fuels like LPG and kerosene.

Table 12.7. Estimate of household fuel demand

City	Population	APROSC (1981/82)*		USAID (1986/87)	
		Demand per capita (kg)	% using fuelwood	Demand per capita (kg)	% using fuelwood
Katmandu	300,446	200	72.5	176	58
Lalitpur	94,294	180	72.5	144	58
Bhaktapur	53,780	160	90.0	128	72

APROSC. A Feasibility Study on the Provision of Fuelwood for Urban Areas, Volumes 1 and II, 1983. Katmandu.

Source: The Forest Products Marketing Systems in Nepal: Case Study of the Urban Areas of Katmandu Valley, Shaikh Asif, M., et. al., United States Agency for International Development, Nepal (1989)

12.8. Fuelwood Demand in Industrial and Commercial Sectors

The result of various surveys on industrial and commercial fuelwood consumption have been compiled and shown in Table 12.8. The sources indicate that army, police and other governmental institutions obtain virtually all of their fuelwood through the Nepal Fuelwood Corporation. In 1986/87, the NFC reported 13,300 tons of sales in Katmandu to these institutions.

Table 12.8.   Fuelwood demand in industry/commerce sector in Katmandu Valley, 1986/87

Source	Estimate (tons)	Year	Coverage
Donovan (1981)	3,441	1986/87	All industrial establishments in the Valley
	20,404		Industry/commerce
World Bank (1983)	25,704	1986/87	Industrial/commercial sectors in Katmandu Valley
APROSC (1983)	26,859	1987	Industrial/commercial sectors in the urban areas of the Valley
USAID (1989)	19,959	1988	Industrial establishments in the Valley covering brick and tile factories, bakeries, chemicals, soaps and carpets.
	26,489		Industry and commerce which includes restaurants, tea shops and sweet shops
	27,295		Industry and commerce where demand for commerce = 36.75% of industry demand, World Bank (1987)

Source: The Forest Products Marketing Systems in Nepal: Case Study of the Urban Areas of Katmandu Valley, Shaikh Asif, M., et. al., United States Agency for International Development, Nepal (1989)

Donovan (1981) estimated the industrial demand for fuelwood in the three districts of Katmandu for 1972/73. This figure was extrapolated to arrive at 1986/87 figures using a population growth rate in the three districts of 4.57 (Katmandu), 3.07 (Lalitpur and 1.91 (Bhaktapur). The demand estimate for commerce was obtained using the ratio of commerce and industry from World Bank 1986/87 estimates.

For 1980/81, *UNDP/World Bank* reported the national fuelwood demand of the industrial/commercial sectors. By multiplying the Katmandu industrial establishment ratio with the national fuelwood demand figure, the industrial demand for Katmandu in 1980/81 was estimated. This figure was then extrapolated to 1986/87 levels using the national population growth rate of 2.67 per cent per annum.

The *APROSC* study estimated urban industrial and commercial fuelwood demands of Katmandu Valley in 1982 by conducting a sample survey. The average requirements of each type of industry were multiplied by the total number of similar industries and added up to arrive at the 1982 demand figure. Using the population growth rate of the 70s, projections were made for 1987.

USAID estimated industrial demand using separate estimates for the brick and tile industries and other industries. Fuelwood consumption in the brick and tile industries was estimated using typical consumption figures from a survey and the number of such industries registered with the department of cottage industries. Typical consumption figures for other industries were taken from an ISC industrial survey and multiplied with the total number of such establishments obtained from the 1980/81 census of manufacturing establishments.

13. PAKISTAN

13.1. The Country

Pakistan extends from the Arabian Sea to the Hindu Kush mountain ranges and covers an area of approximately 80.39 Mha. The greatest distance is 1,872 km NE to SW and 1,006 km SE to NW. The total length of the coastline is 814 km. It shares international boundary lines of 5,847 km with India in the east (2,028 km), 523 km with China in the north-east, 2,466 km with Afghanistan in the north, and 830 km with Iran in the west. Pakistan has four provinces namely Punjab, Sindh, North West Frontier Province (NWFP) and Baluchistan. The central part of the country is well irrigated by the existing canal system and is swept by the monsoon rains for two to three months a year. The northern part of the country consists of forested high mountain valleys with sparse population.

13.2. Population and Land Use

The population of Pakistan was estimated in 1993 as 120.8 million based on its last census in 1981, when the population was 99.2 million. The population is expected to reach 139 million by the year 2000. About 55% of the total population lives in the plains of Punjab and about 68.5% of the population lives in rural areas. The average household size is 7.2 persons. Paradoxically in Pakistan, the urban household size is larger than the rural household size. Population growth in Pakistan is about 3.0% with 4.4% and 2.6% for the urban and rural areas respectively.

Table 13.1 The population and land use data

	Unit	1987	1988	1989	1990	1991	1992	1993
Total population	'000	110,248	114,190	118,097	121,933	125,667	129,314	132,941
Agricultural	'000	60,028	61,612	63,135	64,576	65,918	67,170	68,371
Total land	'000 ha	77,088	77,088	77,088	77,088	77,088	77,088	77,088
Arable + permanent crop land	'000 ha	20,920	21,820	21,020	20,940	20,960	26,460	21,250
Irrigated land	'000 ha	16,310	15,680	16,890	16,940	16,750	16,850	17,110
Forest + woodland	'000 ha	2,920	3,460	3,430	3,380	3,460	3,470	3,480
Fuelwood production*	'000 m^3	21,026	21,718	22,405	23,080	23,737	24,379	25,021

Source: Country Tables, FAO, Rome (1995)   **Includes wood converted to charcoal*

Pakistan's forests and woodlands constitute only 5% of the total land area. About 28% of the land is under permanent crop while another 22% is irrigated land. For the purpose of resource assessment, the country has been stratified into 14 national agro-ecological zones based on satellite imagery data and Geographical Information System data. Details of this zonation of 14 land cover types are given in Table 13.2.

Table 13.2. Pakistan: agro-ecological zonation

Zone	Description	Area* (km^2)	%
1	Hyper-arid desert	58,738	6.7
2	Arid desert	193,604	22.1
3	Transitional arid/semi arid rangelands	117,833	13.4
4	Moderate productivity semi-arid	74,819	8.5
5	High productivity semi arid	61,180	7.0
6	Sub tropical rain fed agriculture	27,878	3.2
7	Permanent snow	25,019	2.9
8	High mountain valleys	18,964	2.2
9	Alpine and temperate scrub/forest	94,747	10.8
10	Temperate/sub-tropical Himalayan foothills	10,637	1.2
11	Marginal irrigated	1,940	0.2
12	Moderate productivity irrigated	74,533	8.5
13	High productivity irrigated	111,717	12.7
14	Indus delta swamps	5,619	0.6
	Total	877,227	100.0

*includes the area of Jammu and Kashmir on the Pakistan side of the Line of Control

Source: Pakistan Household Energy Strategy Study, Government of Pakistan, Under the United Nations Development Programme, World Bank Energy Sector Management Assistance Programme (1994)

13.3. Economy

Pakistan is primarily an agricultural country with cotton and rice being its major export products. It has a free market economy with a predominant private sector. In the last few years, it has developed an industrial base with the establishment of small and medium scale industries. Pakistan is endowed with a reasonable level of natural resources. Apart from agriculture and industries, other economic activities include mining and quarrying, construction, commerce and trade, services, transportation and public utilities.

Table 13.3. Principal economic indicators of Pakistan, 1985-92

Economic indicator	1985	1986	1987	1988	1989	1990	1991	1992	1993
GDP (1987 US$ million)	29,695	31,334	33,353	35,949	37,671	39,355	41,502	44,733	45,621
GDP (current US$ million)	31,148	31,903	33,353	38,473	40,174	40,013	45,625	48,885	51,825
GDP growth (%/year)	7.6	5.5	6.4	7.8	4.8	4.5	5.5	7.8	2.0
GNI/capita (1987 US$)	330	330	340	350	350	360	350	370	370
GNI growth (%/y)	6.2	3.6	6.5	5.7	3.1	5.2	1.4	7.1	1.6
GNP/capita (US$)	360	370	380	410	400	400	400	420	430

Source: World Tables 1995, Published for the World Bank, The Johns Hopkins University Press, Baltimore and London, New York (1995)

In 1979, an expenditure survey showed the share of household income spent on various purposes, Table 13.4. shows the details of this. It is to be noted that about 5 to 6% of the household income is spent for fuel and lighting purposes.

Table 13.4. Distribution of household expenditure in Pakistan, 1979

Item	Pakistan (%)	Rural (%)	Urban (%)
Food & drinks	50.8	55.0	46.3
Clothing & footwear	9.6	10.2	9.0
House & rent	10.0	6.5	15.4
Fuel & lighting	5.2	5.7	4.6
Furniture & fixtures	1.5	1.4	1.5
Miscellaneous	22.1	21.2	23.1
Total	100.0	100.0	100.0

Source: Sociology of Natural Resources in Pakistan and Adjoining Countries, Dove, Michael R., Carpenter, C., Pakistan (1992)

13.4. Pakistan's Energy Situation

Pakistan is an energy deficient country. Of all conventional energy produced, 38.8% is derived from oil, 35% from natural gas, 7.3% from coal, 17.1% from hydroelectric power, 1.7% from nuclear power, and 0.3% from liquefied petroleum gas. About 68% of the energy requirements are met through conventional sources while traditional fuels such as fuelwood, agricultural residues and dung account for the remaining 32%.

Table 13.5. Primary conventional energy production and consumption, 1989-92

Primary energy production	Unit	1989	1990	1991	1992
Solid fuels	ktoe	1,247	1,483	1,441	1,504
Liquid fuels	ktoe	2,392	2,719	3,268	3,841
Gaseous fuels	ktoe	9,230	10,109	10,507	11,162
Electricity	ktoe	1,467	1,531	1,674	1,880
Total conventional production	ktoe	14,336	15,842	16,890	18,387
Total consumption	ktoe	21,946	24,125	24,641	26,074
Per capita consumption	kgoe/capita	191	204	203	209
Fuelwood production	'000 m^3	22,405	23,080	23,737	24,379
	ktoe*	5,130	5,285	5,435	5,582

*Assuming 1 m^3 wood equals 0.23 toe

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

13.5. Energy Consumption Pattern

The energy consumption patterns are different between sectors and also between rural and urban settlements. It is found that the industry and transport sectors rely heavily on conventional fuels such as electricity and fossil fuels whereas traditional fuels such as fuelwood, agricultural residues and dung are the primary source of energy for the majority of the rural population in Pakistan. The current (1993/94) national energy consumption of conventional fuels is estimated at over 23 Mtoe. Locally available traditional fuels supply an additional amount of almost 20 Mtoe of energy primarily to the household sector.

The Pakistan Household Energy Strategy study (HESS) undertaken in 1992 showed that biofuels or traditional fuels account for 86% of total household energy consumption in Pakistan while fuelwood accounts for 54% of the total. Biofuels are basically used in the traditional stoves for cooking, space heating, and water heating.

Natural gas is mainly used in urban areas for cooking and accounts for 51% of all modern fuels consumed in the household sector. Electricity (used for lighting and space cooling) accounts for 30% followed by kerosene (lighting and some cooking) with 16%. The remaining 3.2% is LPG.

Table 13.6. Final conventional energy consumption in Pakistan, 1993-94 (ktoe)

Sector	Coal	Petroleum products	Natural gas	Electricity	Total
Agriculture		321		470	791
Industry	1,560	1,624	3,679	1,029	7,892
Transport		6,740	1	2	6,743
Residential	2	696	1,930	1,151	3,779
Commercial		29	357	207	593
Services		374		185	558
Non energy use	720	337	1,629		2,686
Total	2,282	10,121	7,576	3,044	23,043

Source: Asian Energy News, Asian Institute of Technology, Vol. 5, No. 11, November 1995

Fuelwood plays an important overall role in energy supply, as about 50% of the total population is mainly dependent on fuelwood for meeting energy needs for cooking and heating. According to the 7th five year plan, it is estimated that 90% of rural households and 60% of urban households meet their energy needs by the use of biomass including wood.

Table 13.7. Biomass energy consumption in Pakistan, 1993-94 (ktoe)

	Fuelwood	Other biomass	Total biomass energy
Production	12,219	9,154	21,373
Transport losses	-313	-448	-761
Final consumption	11,906	8,706	20,612
Residential	11,675	6,848	18,523
Commercial	225		225
Industry	6	1,858	1,864

Source: Asian Energy News, Asian Institute of Technology, Vol. 5, No. 11, November 1995

Table 13.8. shows the average levels of consumption by households in 1991 in physical units as estimated by the HESS demand survey.

Table 13.8. Average annual household fuel consumption, 1991

Fuel	Quantity
Fuelwood	2,324 kg
Dung	1,477 kg
Crop residues	1,161 kg
Charcoal	115 kg
Electricity	1,238 kWh
Natural gas	40,220 ft^3
Kerosene	41 kg
LPG	122 kg

Source: Pakistan Household Energy Strategy Study, Government of Pakistan, Under the UNDP, World Bank Energy Sector Management Assistance Programme (1994)

Cooking is the major end use for fuelwood, crop residues, dung, natural gas and LPG. More specialized end uses like lighting are met by fuels such as electricity and kerosene whereas space cooling is met only by electricity.

Table 13.9. Household fuel consumption by end use (ktoe)

Fuel	Cooking	Space heating	Water heating	Lighting	Space cooling	Other	Total
Electricity	0	0	0	304	319	228	851
Natural gas	1,212	59	144	0	0	0	1,415
LPG	90	0	0	2	0	0	92
Kerosene	49	0	0	376	0	17	442
Fuelwood + charcoal	8,623	863	1,064	0	0	206	10,756
Dung	3,429	0	0	0	0	184	3,613
Crop residues	2,281	225	282	0	0	28	2,816
Total	15,684	1,148	1,489	682	319	663	19,985

Source: Pakistan Household Energy Strategy Study, Government of Pakistan, Under the UNDP, World Bank Energy Sector Management Assistance Programme (1994)

Traditional fuels account for 95% of energy consumption in rural households whereas in urban households this share is 56%. The 69% of Pakistan's population, living in rural areas account for 77% of the total household energy consumption. 71% of modern fuel use is concentrated in urban areas.

Table 13.10. Urban/rural household fuel consumption (ktoe)

Sector	Elect.	Gas	LPG	Kerosene	Total comm	Wood	Dung	Crop res	Char-coal	Total trad.	Total
Urban	475	1,359	57	90	1,980	1,708	511	286	17	2,523	4,502
Rural	376	0*	36	353	764	8,926	3,103	2,529	102	14,660	15,425
Pakistan	851	1,416*	92	443	2,802	10,637	3,613	2,816	119	17,185	19,988

Notes: The data on the rural section was omitted since it was not statistically significant. However, the data under the head 'Pakistan' includes the combined data for rural and urban areas.

Results rounded to nearest TOE may not sum up exactly.

Source: Pakistan Household Energy Strategy Study, Government of Pakistan, Under the UNDP, World Bank Energy Sector Management Assistance Programme (1994)
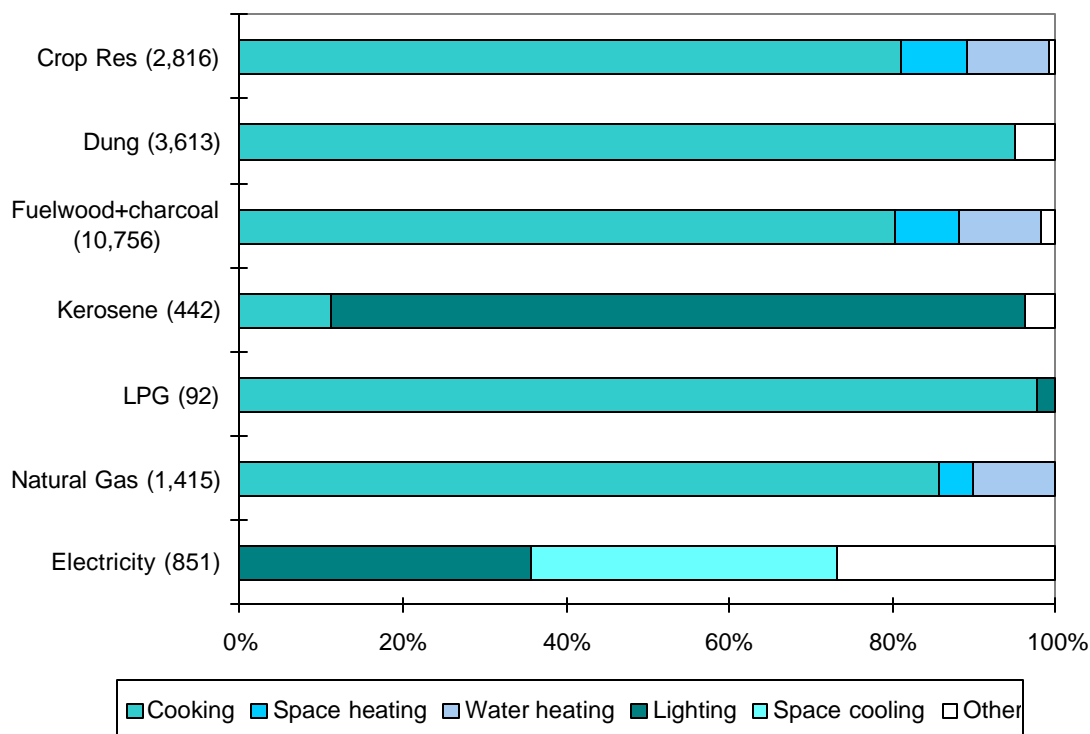
Figure 13.2. Household fuel consumption pattern (HESS, 1994)

13.6. Fuelwood Consumption in Industry

In a survey conducted for Winrock International, it was found that bricks and tiles are usually baked using wood and coal together. Out of 12,345 million bricks and tiles produced in Pakistan, 98.5% is produced with coal and firewood, the remaining 178 million are made using only wood. About 321 m^3 of wood is required to produce 1 million bricks/tiles. The most popular species of wood used are Babul (Acacia nilotica) followed by Shisham (Dalbergia sissoo) and Ber (Zizyphus mauritiana). About 97% of the kiln owners purchase firewood from the private sector through middlemen or directly from the wood market. Only 3% of the kiln owners are dependent on government forests for their wood requirements. In another study by Winrock International, fuelwood consumption in tobacco curing industries was estimated as follows:

Table 13.11. Fuelwood consumption in tobacco curing industries

Year	Area under tobacco (ha)	No of barns	Av. wood cons. per barn per season (kg/season)	Total annual consumption (tons)
1988	11,871	11,378	6,986	79,487
1989	10,971	10,516	6,986	73,465
1990	11,744	11,257	6,986	78,641

Source: Wood Consumption Survey in the Flue-Cured Virginia Tobacco Industry, Khattak, G.M., Iqbal, Muhammad, Winrock International, Islambad (1990)

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13.7. Fuelwood Resources

Under the "Pakistan Household Energy Strategy Study", an attempt was made to assess biomass resources in Pakistan. For this purpose, a national agro-ecological zonation exercise was created using multi-temporal Advanced Very High Resolution Radiometer (AVHRR) satellite imagery to distinguish between patterns of vegetation activity over time. The satellite imagery was obtained as monthly composites of daily images covering six annual seasons from 1982-87, then combined with ancillary Geographical Information System (GIS) data on rainfall, topography, climate, and the extent of irrigated farmland to produce a zonation of 14 land cover types for Pakistan. The details of these zones are shown in Table 13.2. The next stage consisted of twelve scenes of Landsat Thematic Mapper imagery for more detailed classification of the vegetation. Sampling units were then selected by variable probability sampling from the digital vegetation classification from each Landsat scene for field measurement of woody biomass and crop residues. All woody biomass was measured including commercial timber trees, all other tree species and woody shrubs. Mathematical models were developed from destructive sampling of trees and shrubs to predict their biomass content by component. Mathematical models were also developed to allow for the effects of crown damage due to lopping on tree biomass and growth. Thus the woody biomass resource and annual productivity was estimated for each agro-ecological zone. Dove (1989) has estimated that:

-Total standing stock   =   210.78 million tons
-Total annual wood growth   =   22.70 million tons
-Total fuelwood growth   =   20.13 million tons
-Twigs/leaves growth   =   10.10 million tons
-Round wood fuel growth   =   10.03 million tons

Despite the fact that Pakistan's households are currently consuming approximately 10 million tons more than can be sustainably produced, fuelwood will continue to supply the largest share in the near future. At present fuelwood prices do not demonstrate any depletion effects and in general fuelwood markets in Pakistan have worked efficiently to ensure that those wanting to utilize fuelwood are supplied with it.

14. PHILIPPINES

14.1. The Country

The Philippine archipelago consists of some 7,100 islands and islets, of which only 700 are inhabited. The 11 islands that are larger than 2,590 km^2 account for 95% of the area of 30 Mha; Luzon and Mindanao together account for 65%. The Philippines extends 1,851 km SSE to NNW and 1,062 km ENE to WSW. Luzon, Mindanao and the Visayas Islands are generally considered as three separate geographical regions. Luzon, like Mindanao, is a series of peninsulas joined together by plateaus and lowland strips. It accounts for over one third of the national territory and is 400 km in length and generally between 120 and 160 km in width but 222 km at its widest.

14.2. Population and Land Use

The population of the Philippines was estimated in 1985 at 56.80 million on the basis of the official census held in 1980, when the population was 48.1 million. The population is expected to reach 78 million by 2000. The population growth rate is estimated at 2.5% per year on the basis of an estimated birth rate of 32.3 per 1,000 per year. The population density is 182 per km^2 overall and 442 per km^2 in agricultural areas. The average family size is 5.6 members.

Table 14.1. Population and land use data

	Unit	1987	1988	1989	1990	1991	1992	1993
Total population	'000	57,107	58,304	59,521	60,779	62,084	63,427	64,800
Agricultural	'000	27,393	27,685	27,974	28,264	28,555	28,844	29,133
Total land	'000 ha	29,817	29,817	29,817	29,817	29,817	29,817	29,817
Arable + permanent crop	'000 ha	9,020	9,060	9,080	9,130	9,150	9,190	9,190
Irrigated land	'000 ha	1,490	1,510	1,540	1,560	1,580	1,580	1,580
Forest + woodland	'000 ha	13,600	13,600	13,600	13,640	13,600	13,600	13,600
Fuelwood production*	'000m^3	31,189	31,948	32,703	33,448	34,213	35,254	35,980

Source: Country Tables, FAO (1995)   ** Includes wood converted to charcoal*

About 46% of the total land area of the Philippines is under forest cover. Arable and permanent crop land constitutes about 30.8% and irrigated land constitutes 5%.

14.3. Economy

The Philippine economy is basically agricultural. About 51% of the economically active population in 1970 was engaged in agriculture. It is one of the 39 lower middle income countries of the world with a free market economy with a predominant private sector. The principal economic indicators of the country are given in Table 14.2. As of 1990, the average inflation rate was 12.7%.

Table 14.2 Major economic indicators of Philippines, 1985-92

Economic indicators	1985	1986	1987	1988	1989	1990	1991	1992	1993
GDP (1987 US$ million)	30,768	31,821	33,196	35,441	37,645	38,653	38,572	38,682	39,440
GDP (current US$ million)	30,735	29,868	33,196	37,885	42,575	44,311	45,417	52,977	54,068
GDP growth (%/year)	-7.3	3.4	4.3	6.8	6.2	2.7	-0.2	0.3	2.0
GNI/capita (1987 US$)	540	550	570	620	630	630	620	620	610
GNI growth (%/year)	-3.4	4.3	5.8	10.1	3.7	3.0	0.6	1.7	1.3
GNP/capita (US$)	520	560	610	680	720	750	760	800	850

Source: World Tables 1995, Published for the World Bank, The Johns Hopkins University Press, Baltimore and London, New York (1995)

14.4. Energy Situation

In the past, the Philippines relied heavily on imported oil for its energy requirements. Of the total consumption volume of 9,380 ktoe in 1973, 92% was accounted for by imported oil. In 1979 the share of imported energy declined to 72.4%. With efforts to increase the production of hydropower and geothermal energy, the country's energy self sufficiency ratio improved to about 44.3%. of the total energy demand.

Table 14.3 Energy production and consumption data

	Unit	1989	1990	1991	1992
Solid fuels	ktoe	584	588	597	786
Liquid fuels	ktoe	267	245	165	418
Gaseous fuels	ktoe	-	-	-	-
Electricity	ktoe	5,121	5,213	5,384	5,259
Total conventional production	ktoe	5,972	6,047	6,147	6,462
Total consumption	ktoe	16,632	17,390	18,073	18,442
Per capita consumption	kgoe/capita	272	279	283	283
Fuelwood production	'000 m^3	32,703	33,448	34,213	35,038
	ktoe*	7,488	7,659	7,834	8,023

*estimated using 1 m^3 of wood = 0.23 toe

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

The total recorded energy produced in the country in 1987 was 583 PJ. The amount of energy based on household and industrial firewood is about 38% of the total energy consumption. In 1992, total indigenous production of conventional energy amounted to 6,462 ktoe and the consumption of 18,442 ktoe which gives a per capita consumption of 291 kgoe/capita. According to the energy balance for the year 1992 prepared by AEEMTRC for the Asean Energy Review, the residential and commercial sector consumed about 11,405 ktoe of energy including traditional energy. This citation gives a total consumption of 21,145 ktoe including traditional energy sources.

Table 14.4. Energy balance table for the Philippines (ktoe), 1991

| | Primary | | | | | | Secondary | | Petroleum | Non- | |
	Fuelwood	Others	Hydro	Geothermal	Coal	Oil	Charcoal	Electricity	Products	Energy	Total
Indigenous production	9,601	2,311	1,281	1,433	606	156			0		15,388
Import					651	10,303			1,736		12,690
Export											0
Stock changes					-96	2			0		-94
Gross primary supply	9,601	2,311	1,281	1,433	1,161	10,461	0	0	1,736	0	27,984
Energy transformation	-4,017		-1,281	-1,433	-509	-10,871	1,375	1,872	7,008	266	-7,590
Net supply	5,584	2,311	0	0	652	-410	1,375	1,872	8,744	266	20,394
Exports									-1,041	-2	-1,043
Bunkers									-407		-407
Net domestic supply	5,584	2,311	0	0	652	-410	1,375	1,872	7,296	264	18,944
Statistical difference	0	0	0	0	142	410	-2	-33	-343	-72	102
Net dom. consumption	5,584	2,311	0	0	794	0	1,373	1,839	6,952	192	19,045
Industry		1,959			794		0	803	1,613		5,169
Residential	5,584	352					1,373	954	1,156		9,419
Transport								2	3,975		3,977
Agriculture								0	0		0
Others								80	208		288
Non-energy use									0	192	192

Source: ASEAN Energy Review, Volume 3, May 1993, ASEAN-EC Energy Management Training And Research Centre, Jakarta, (1994)

14.5. Energy Consumption Pattern in the Household Sector

The Philippines had about 10.8 million households in 1989. The majority of the population lives in the countryside because of the climatic conditions conducive to crop raising and availability of aquatic resources. From the 1992 energy consumption data, approximately 54% of the total energy is consumed in the residential and commercial sectors out of which 49% is from traditional energy sources (mainly fuelwood). Energy consumption figures for rural and urban households for the years 1977 and 1989 are given in Table 14.5.

Table 14.5.   Total household energy consumption by fuel type in urban and rural areas (ktoe)

| | Urban | | Rural | | Philippines | |
Fuel sources	1977	1989	1977	1989	1977	1989
Conventional	449	667	506	361	1,016	1,028
Electricity	81	341	49	103	131	444
LPG	76	176	35	55	111	231
Kerosene	292	150	482	203	774	353
Traditional	996	702	1,824	2,869	2,818	3,571
Fuelwood	686	508	1,014	2,350	1,699	2,858
Charcoal	272	94	456	113	727	207
Crop residues.	38	100	354	406	392	506
Total residential	1,445	1,369	2,390	4,230	3,834	4,599

Source: Sectoral Energy Demand in the Philippines, Regional Energy Development Programme, United Nations, Bangkok (REDP, 1992)

According to the above data, it is clear that the share of traditional fuels in the rural sector has increased. In 1989, traditional fuels delivered about 78% of the energy in all households, whereas in 1977 this was 74%. Wood makes up 80% of the traditional fuels used, crop residues and charcoal only 14 and 6%, respectively. The major end use of energy in the domestic sector is cooking, followed by lighting and refrigeration. Fuelwood is the main fuel used for cooking.
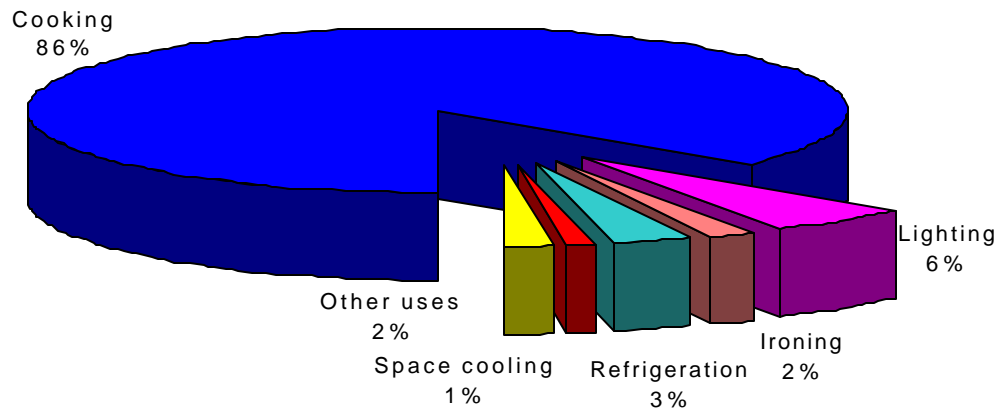

Fig. 14.1 Household energy consumption by end use in 1989 (REDP, 1992)

14.6. Industrial Fuelwood Consumption

A report on the 1990 fuelwood consumption survey by the Office of Energy Affairs has determined the national and regional fuelwood consumption levels of the industrial sector. The survey estimated that about 39% of the establishments and industries consumed fuelwood or a fuelwood substitute. In some regions, the majority of establishments consumed fuelwood. Of all fuelwood or fuelwood substituting industries, 77% used fuelwood, the remaining 23% used fuelwood substitutes. The survey indicated that the following forms of woodfuels are used by these industries:

- Tree roots/ stems/ barks/ branches / twigs / stumps
- Log cores / ends / slabs / trimmings / edgings
- Chopped pieces of wood, board
- Sawdust.
- Charcoal

In 1990, the estimated consumption of fuelwood or fuelwood substitutes by business establishments in the Philippines totaled 14.15 million m^3. Of this, fuelwood comprised 7.82 million m^3 or 55% while fuelwood substitutes comprised 6.33 million m^3 or 45%. The major end users in this sector are bakeries, restaurants, eateries, prepared food vendors, poso makers, snack food vendors etc. Fuelwood consuming institutions are schools, hospitals, and prisons. The shares of various traditional fuels are fuelwood (58.3%), coconut shells (22.6%), scrap wood (17.3%) and bamboo (1.8%).

It is to be noted that 89% of the fuelwood used in industries is purchased from various sources, only 9% is collected free. 99% of the purchased fuelwood originated from the same province.

15. SRI LANKA

15.1. The Country

The island of Sri Lanka has a total area of 6.56 Mha and a total coastline of 1,204 km. The longest distance north-south is 435 km and east-west 225 km.

Sri Lanka has two geographical regions: a central hill region, surrounded by more extensive low land plains. More precisely, a flat or gently rolling plain occupying 80 per cent of the country makes up the entire northern half of the country. The southern-central part is hilly and mountainous ranging from 900-2,100 meters above sea level. The population is concentrated in the south western area, which receives rainfall from two monsoons. The country is divided into 25 administrative districts and it is these which generally provide the basic units within which official statistics are collected and made available.

15.2. Population and Land Use

The population of Sri Lanka was estimated at 16.2 million in 1985 based on the official census held in 1981, when the population was 14.8 million. The population is expected to reach 21 million by the year 2000. The annual growth rate is about 2.03% at a birth rate of 27 per 1,000 with a density of 250 per km^2. The urban component of the population is 21% with an annual growth rate of 1.6%. The average size of the family in Sri Lanka is estimated as 5.2.

Table 15.1 Population and land data

	Unit	1987	1988	1989	1990	1991	1992	1993
Total population	'000	16,574	16,792	17,007	17,225	17,447	17,671	17,897
Agricultural	'000	8,651	8,735	8,819	8,903	8,989	9,075	9,163
Total land	'000 ha	6,463	6,463	6,463	6,463	6,463	6,463	6,463
Arable + permanent crop	'000 ha	1,895	1,898	1,901	1,900	1,903	1.905	1,900
Irrigated land	'000 ha	530	592	494	520	530	550	550
Forest + woodland	'000 ha	2,010	2,026	2,043	2,082	2,178	2,100	2,100
Fuelwood production*	'000 m^3	8,078	8,183	8,287	8,349	8,456	8,604	8,703

Source: Country Tables, FAO, Rome (1995)   **Includes wood converted to charcoal*

About 32% of the land area of Sri Lanka is under forest cover and the permanent crop land constitutes around 15% of the land area, followed by 2% of irrigated land.

15.3. Economy

Table 15.2 shows the major economic indicators for Sri Lanka for the years 1985 to 1993.

Table 15.2 Major economic indicators of Sri Lanka, 1985-1993

Economic indicators	1985	1986	1987	1988	1989	1990	1991	1992	1993
GDP (constant 1987 US$ mill)	6,447	6,720	6,800	6,983	7,132	7,581	7,921	8,245	8,815
GDP (current US$ million)	6,078	6,517	6,800	7,128	7,096	8,140	9,104	9,859	10,472
GDP growth (%/year)	5.1	4.2	1.2	2.7	2.1	6.3	4.5	4.1	6.9
GNI/capita (1987 US$)	390	390	400	400	400	420	430	440	470
GNI growth (%/year)	-0.7	1.5	3.9	1.1	1.8	5.1	3.8	5.1	7.9
GNP/capita (US$)	370	400	430	460	450	470	500	550	600

Source: World Tables 1995, Published for the World Bank, The Johns Hopkins University Press, Baltimore and London, New York (1995)

15.4. Energy Situation

Sri Lanka has no oil or natural gas reserves. Forest products and agricultural residues are of central importance to Sri Lanka's overall energy supply. Estimates suggests that these fuels cover about 67% of the gross and 38% of the useful energy consumption. The details of energy production and consumption in Sri Lanka are given in Table 15.3.

Table 15.3 Primary energy production and consumption in Sri Lanka

Primary energy production	Unit	1989	1990	1991	1992
Solid fuels	ktoe	-	-	-	-
Liquid fuels	ktoe	-	-	-	-
Gaseous fuels	ktoe	-	-	-	-
Electricity	ktoe	241	270	268	249
Total conventional production	ktoe	241	270	268	249
Total consumption	ktoe	1,351	1,527	1,627	1,855
Per capita consumption	kgoe/capita	79	89	93	105
Fuelwood production	'000 m^3	8,960	9,021	9,080	9,100
	ktoe*	2,052	2,066	2,079	2,084

*Converted using 1 m^3 wood = 0.23 toe

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

Table 15.4. Average household income (Rs/Month)

Year	Urban	Rural	Estate	All island
1978-1979	879	661	605	669
1981-1982	2,665	1,562	1,105	1,730
1986-1987	4,246	2,397	1,830	2,728

Source: Sectoral Energy Demand in Sri Lanka, Regional Energy Development Programme, United Nations, Bangkok (REDP, 1992)

15.5. Pattern of Energy Consumption in the Household Sector.

Fuelwood is used for cooking. Only 2% of the fuelwood consuming households are using it for other purposes such as ironing clothes, heating, brewing beverages etc. Kerosene is the second most common cooking fuel though it is mostly used for lighting. Fuelwood is still extensively used in the capital Colombo, although the living standard, employment and housing are much

different from the other parts of the country. The market share of fuelwood is high due to the fact that alternative energy sources are expensive and not readily available.

Table 15.5. Household consumption for cooking 1986-87.

Sector	Fuelwood		Kerosene		Electricity		LPG		Others*
	Mt/y	%	kl/y	%	GWh/y	%	Mt/y	%	%
Urban	422	79.0	177	2.4	1,534	3.5	1,408	12.6	2.5
Rural	2,634	98.5			45	0.2	9	0.4	0.9
Estate	378	99.5			4	0.3	-		0.2
Total	3,434	95.1	177	0.5	1,583	0.8	1,417	2.5	1.1

* Includes charcoal, sawdust and crop residues.

Source: Sectoral Energy Demand in Sri Lanka, Regional Energy Development Programme, United Nations, Bangkok (REDP, 1992)
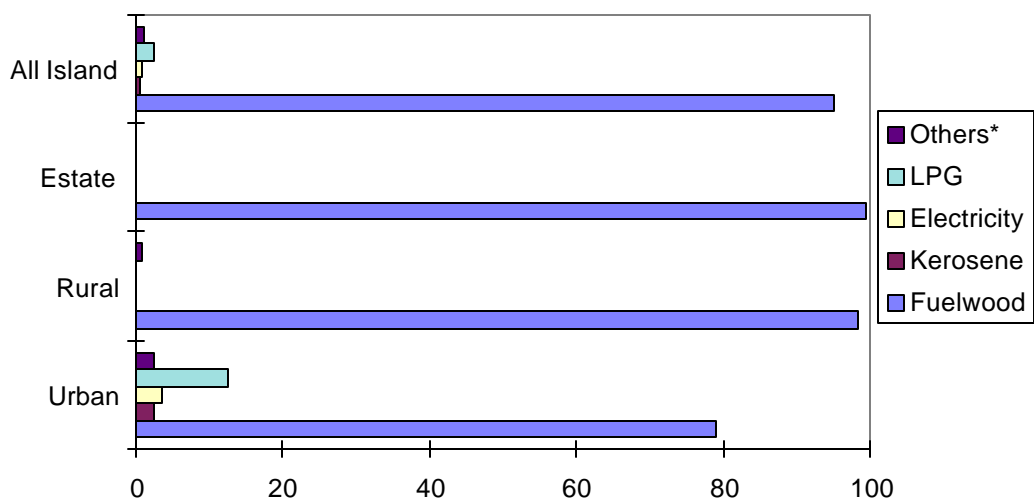

Fig 15.1 Share of fuels by sector (REDP, 1992)

The bulk of fuelwood is consumed in the rural sector. With a lack of alternative fuels, fuelwood accounts for the major share of energy for cooking. The estate sector has the highest average fuelwood consumption reflecting the inefficient cooking facilities and good availability of fuelwood. The average fuelwood consumption in the urban sector is relatively low since more energy efficient burning facilities are used and fuelwood is more expensive compared to rural and estate areas. To a certain extent the consumption depends also on the purchasing power of the people and the price of the fuelwood.

Table 15.6 Consumption of fuelwood in 1985

Region	Fuelwood consumption			Share of population (%)	Land area (%)
	(kton)	(kg/capita/y)	(%)		
Colombo	672	450	8.5	11.5	1.0
Northern wet	1,924	510	24.2	24.4	15.2
Southern wet	1,637	513	20.6	20.5	12.0
Up country	1,383	626	17.4	14.6	9.9
Southeast dry	803	520	10.1	9.4	23.5
Central dry	945	525	11.9	11.5	24.9
Northern dry	585	495	7.3	7.6	13.5
Total	7,949	523 (Average)	100.0	100.0	100.0

Source: Forestry Master Plan for Sri Lanka, Annex V Wood Demand and Market Study; Forest Resources Development Project; Sri Lanka Agreement and World Bank/Govt. of Sri Lanka Credit Agreement by Jaakko Poyry International Oy in Collaboration with Sri Lanka Authorities, Helsinki (1986)

The socio-economic survey conducted by the central bank indicates the various fuelwood types and their share in different households. The survey was carried out in May 1985 with the data for 1981/81. The findings are given in Table 15.7 below.

Table 15.7. Fuelwood types and sectoral share (%)

Wood type	Urban	Rural	Estate
Coconut	11	30	6
Rubber wood	46	12	22
Tea	1	2	36
Palmyrah	-	1	-
Cinnamon	3	2	-
Forest plantation	-	2	13
Home garden	6	21	9
Private holding	1	5	1
Natural forest	27	21	12
Other	5	4	1
Total	100	100	100

Source: Forestry Master Plan for Sri Lanka, Annex V Wood Demand and Market Study; Forest Resources Development Project; Sri Lanka Agreement and World Bank/Govt. of Sri Lanka Credit Agreement by Jaakko Poyry International Oy in Collaboration with Sri Lanka Authorities, Helsinki (1986)

15.6. Mode of Fuelwood Procurement

In urban areas, about 64% of the fuelwood is purchased. Most of the wood from natural forests and half of the rubber wood from the estates is purchased whereas most of the coconut wood is collected free of charge from nearby coconut growing areas.

In the rural and estate areas, 35% of the wood is purchased. Of this, 25% is forest wood. Tea uprooting, coconut wood and rubber wood constitute 40-50%.

The most common types of purchased fuelwood are rubber wood (28%) and coconut (24%). Then comes natural forests (24%) followed by home gardens (11%) and cinnamon (4%). The remaining (3%) are other forest plantations. Fuelwood is purchased from several sources. It is

supplied by shops, depots, distributors using fuelwood carts, sawmills and others. In the estate sector fuelwood is sold by the estate owner. In the urban and rural sector the volume is split between all types of fuelwood suppliers.

Table 15.8 Sources of supply for purchased fuelwood (%).

Zone	Boutique	Depot	Cart	Sawmill	Others	Total
Colombo	9	39	16	14	22	100
Northern wet	8	20	37	8	27	100
Southern wet	32	13	18	3	34	100
Up country	38	21	15	3	23	100
Southeast dry	8	-	58	8	26	100
Central dry	5	26	34	-	35	100
Northern dry	30	34	-	10	26	100
Sector						
Urban	14	25	27	10	24	100
Rural	22	18	28	4	28	100
Estate	12	-	-	-	88	100

Source: Forestry Master Plan for Sri Lanka, Annex V Wood Demand and Market Study; Forest Resources Development Project; Sri Lanka Agreement and World Bank/Govt. of Sri Lanka Credit Agreement by Jaakko Poyry International Oy in Collaboration with Sri Lanka Authorities, Helsinki (1986)

People collect fuelwood mainly from government forests and home gardens; in the estate sector the plantations are the main source. In urban areas a great many households collect fuelwood from other unspecified sources. For example, a great amount of wood is transported to Colombo for processing and part of it ends up as fuelwood. The government forests are tapped for fuelwood in the northern wet and central dry zones and relatively little in the southern wet zone. There and in the northern dry zone people collect fuelwood predominantly from home gardens, due to the limited extent of government forests.

Table 15.9 Sources of collected fuelwood (%)

Zone	Government forests	Home gardens	Private holdings	Government estates	Others	Total
Colombo	-	38	-	22	40	100
Northern wet	55	25	4	-	16	100
Southern wet	10	63	16	9	2	100
Up country	24	22	31	9	2	100
Southeast dry	24	22	31	9	14	100
Central dry	55	22	16	-	7	100
Northern dry	-	58	42	-	-	100
Sector						
Urban	14	24	3	20	39	100
Rural	33	38	11	2	16	100
Estate	6	14	48	19	13	100

Source: Forestry Master Plan for Sri Lanka, Annex V Wood Demand and Market Study; Forest Resources Development Project; Sri Lanka Agreement and World Bank/Govt. of Sri Lanka Credit Agreement by Jaakko Poyry International Oy in Collaboration with Sri Lanka Authorities, Helsinki (1986)

Forestry products and agricultural by-products are of central importance to Sri Lanka's overall energy supply. Estimates suggest that these sources contribute approximately 67% to gross and 38% of the useful energy consumption. 88 per cent of all biomass fuels are consumed by the domestic sector, where it satisfies 94% of the demand. The remaining 12% of biomass is used by industries, where it meets 68% of their total requirements.

15.7. Sources of Traditional Fuels

Biomass fuels used by domestic and industrial consumers come from a wide range of sources and can be grouped in three categories as explained below:

• Fuelwood found in sufficient physical density and sufficient species concentration to be economically transported beyond the boundaries of the district. This includes the wood products of the natural forests of the Dry Zone and of the Wet Zone rubber and coconut plantations. This category accounts for, by far, the greatest portion of fuels which are commercially transacted and for nearly all industrial biomass fuel consumption.

• Fuelwood which is found in smaller concentrations. These fuels have not been commercialized to any great extent, but provide a product of relatively good quality for domestic use.

• Crop wastes from plantations and home gardens such as from coconut shells, tea wastes and palmyrah leaves.

Table 15.10 Annual potential fuel production by source (1985-90)

Categories and fuel source	Production			
	kton		%	
Exportable fuelwood	9,556		57.8	
Rubber		2,012		12.2
Coconut		204		1.2
Forest		7,340		44.4
Other fuelwood	2,128		12.8	
Home garden		898		5.4
Sparsely used cropland		820		5.0
Cinnamon		154		0.9
Tea shade trees		151		0.9
Other		105		0.6
Other fuels	4,759		28.8	
Home garden		1,270		7.7
Coconut		2,107		12.7
Palmyrah		331		2.0
Tea		920		5.6
Other		131		0.8
Total	16,443		100.0	

Source: Farmers, Forests and Fuel: Towards a New Biomass Energy Strategy for Sri Lanka, Howes, M. et al, Intermediate Technology Publications (1995)

16. THAILAND

16.1. The Country

Thailand has an area of 5.14 Mha, extending 1,555 km N to S and 790 km E to W. The land area includes numerous offshore islands. Thailand shares its international boundary of 4,932 km with Myanmar (1,799 km), Malaysia (576 km), Cambodia (803 km) and Laos (1,754 km).

On the basis of natural terrain, there are five distinct topographical regions: the south coast, the northeastern region, the central lowland region, the northern and western mountain region and the southern peninsular region. Thailand has a tropical climate dominated by monsoons.

16.2. Population and Land Use

The population of Thailand was estimated in 1985 at 52.7 million on the basis of the official census held in 1980 when the population was 46.9 million. The population is expected to reach 68 million by the year 2000. The overall population density was 113 per km^2 in 1993. About 40% of the population is concentrated in the central lowlands. Thailand is predominantly a rural nation, with 85% of its population living in three types of villages: strip villages, along both sides of a river or canal, cluster villages, in river valleys and around farm lands and the dispersed villages in the delta regions. The average household size is 5.3.

Table 16.1 Population and land use data

	Unit	1987	1988	1989	1990	1991	1992	1993
Total population	'000	52,967	53,892	54,773	55,583	56,312	56,972	57,585
Agricultural	'000	33,167	33,356	33,505	33,604	33,649	33,647	33,603
Total land	'000 ha	51,089	51,089	51,089	51,089	51,089	51,089	51,089
Arable + permanent crop	'000 ha	20,490	20,568	20,567	20,603	20,726	20,800	20,800
Irrigated land	'000 ha	3,996	4,121	4,158	4,238	4,349	4,400	4,400
Forest + woodland	'000 ha	14,607	14,380	14,342	13,998	13,670	13,500	13,500
Fuelwood production*	'000 m^3	32,687	33,103	33,524	33,948	34,393	34,855	35,313

Source: Country Tables, FAO, Rome (1995)   **Includes wood converted to charcoal*

Forest and woodlands cover about 26% of the total land area. As much as 41% of the land area is under permanent crop along with 8% of irrigated land.

16.3. Economy

Thailand has a free market economy with a predominant private sector. The Thai economy is basically an agricultural one. The major economic indicators for the country for the years 1985 to 1992 are given in Table 16.2. Over the last few years, the Thai economy has grown tremendously. 15% of the national income is received by the lowest 40% and 50% of the national income is received by the highest 20%.

Table 16.2 Basic economic indicators

Economic Indicators	1985	1986	1987	1988	1989	1990	1991	1992	1993
GDP (const. 1987 MUS$)	43,672	46,109	50,535	57,250	64,215	71,759	77,522	83,381	89,899
GDP (current US$ million)	38,900	43,097	50,535	61,668	72,251	85,640	98,742	111,546	124,862
GDP growth (%/y)	4.7	5.6	9.6	13.3	12.2	11.7	8.0	7.6	7.8
GNI/capita (1987 US$)	830	870	950	1,070	1,170	1,270	1,350	1,450	1,540
GNI growth (%/y)	0.1	6.2	10.7	14.6	11.6	10.8	7.9	9.0	8.2
GNP/capita (US$)	810	850	980	1,190	1,350	1,530	1,700	1,910	2,110

Source: World Tables 1995, Published for the World Bank, The Johns Hopkins University Press, Baltimore and London, New York (1995))

16.4. Energy Situation

Until 1981, almost all crude and petroleum products consumed in Thailand were imported. In 1982, Thailand produced 3.1 Mtce and consumed 16.5 Mtce with a national energy deficit of 13.4 Mtce. Thailand has proven reserves of lignite (2,500 million tons), natural gas (15,000 BCF), and crude oil (400 million bbl).

Table 16.3 Primary energy production and consumption, 1989-1992

Primary energy production	Unit	1989	1990	1991	1992
Solid fuels	ktoe	2,323	3,242	3,834	4,018
Liquid fuels	ktoe	2,330	2,820	3,269	3,592
Gaseous fuels	ktoe	4,976	5,400	6,706	7,188
Electricity	ktoe	479	428	394	364
Total conventional production	ktoe	10,108	11,890	14,204	15,163
Total consumption	ktoe	24,656	29,265	32,319	34,883
Per capita consumption	kgoe/capita	457	535	583	621
Fuelwood production	'000 m^3	35,962	34,411	33,538	60,838
	ktoe*	8,235	7,879	7,679	13,931

*Converted using 1 m^3 wood = 0.23 toe.

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

The figures on fuelwood production in table 16.3 do not correspond with the ones in table 16.1. Table 16.1 shows an increase of fuelwood production, whereas table 16.3 shows a decreasing trend with a sudden strong increase in 1992, which makes these latter data seem less reliable.

The social and economic transformations in the Thai society over the last two decades have resulted in a higher per capita income and a rapid growth in energy consumption. Consequently, the share of traditional fuels in the total supply of energy has been declining, but in absolute terms the production and consumption has been decreasing.

16.5. Energy Consumption Pattern

In 1994, traditional sources delivered 26% of the total energy consumption.

Table 16.4 Thailand's traditional energy balance-1994 (ktoe)

Commodity transaction	Fuelwood	Charcoal	Bagasse	Paddy husk	Total
Primary supply	16,221	7	2,667	483	19,378
Transformation	-12,319	4,451	0	-33	-7,901
Total final consumption	3,902	4,458	2,667	450	11,477

Source: Thailand Energy Situation, 1994, Department of Energy Development and Promotion, Ministry of Science, Technology and Environment, Bangkok (1994)

In Thailand the transport sector holds the maximum share of final energy consumption consuming 16,341 ktoe or 37% of the total followed by the manufacturing sector with a consumption of 13,917 ktoe or 32%. The household sector comes next with a consumption of 11,647 ktoe or 27% of the total final consumption of 43,848 ktoe in 1994.

Household energy demand in Thailand has changed substantially during the past 25 years. In the urban areas there has been a shift towards using modern fuels for lighting and cooking. Also the use of air-conditioning and household appliances has become widespread.

Table 16.5 Energy consumption in the household sector, 1994 (ktoe)

Area	Conventional energy				Traditional energy				Total
	LPG	Kerosene	Electricity	Subtotal	Fuelwood	Charcoal	Rice husk	Subtotal	
Bangkok	272	-	476	748	4	16	-	20	768
Municipal	132	-	284	416	4	34	-	38	454
Sanitary	59	1	106	166	24	46	-	70	236
Rural	400	22	656	1,078	3,094	4,362	2	7,458	8,536
Total	863	23	1,522	2,408	3,126	4,458	2	7,586	9,994

Source: Thailand Energy Situation, 1994, Department of Energy Development and Promotion, Ministry of Science, Technology and Environment, Bangkok (1994)

Table 16.5 shows that about 76% of the household energy is traditional, whereas in rural areas it was 87% for the year 1994. It is observed that the highest household energy requirement is for cooking, followed by lighting, refrigeration and air conditioning. Rural households consumed 64% of the total energy required by this sector but on a per capita basis urban households consumed more than rural households (0.43 vs. 0.31 toe).
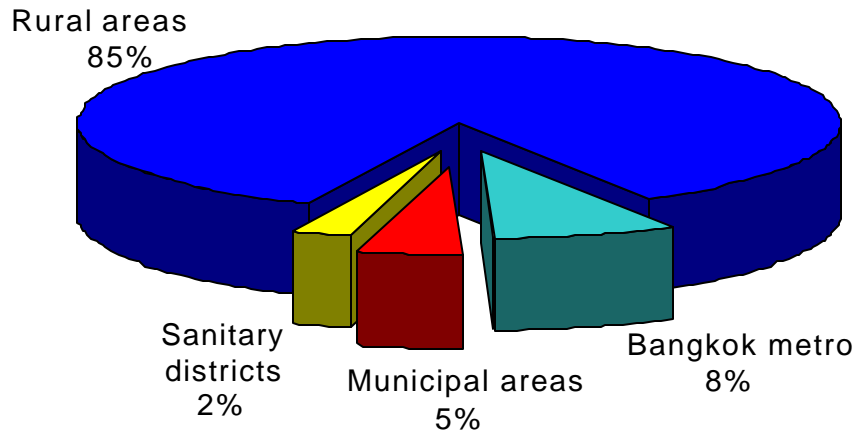
Fig 16.1 Residential energy consumption by area (DEDP, 1994)
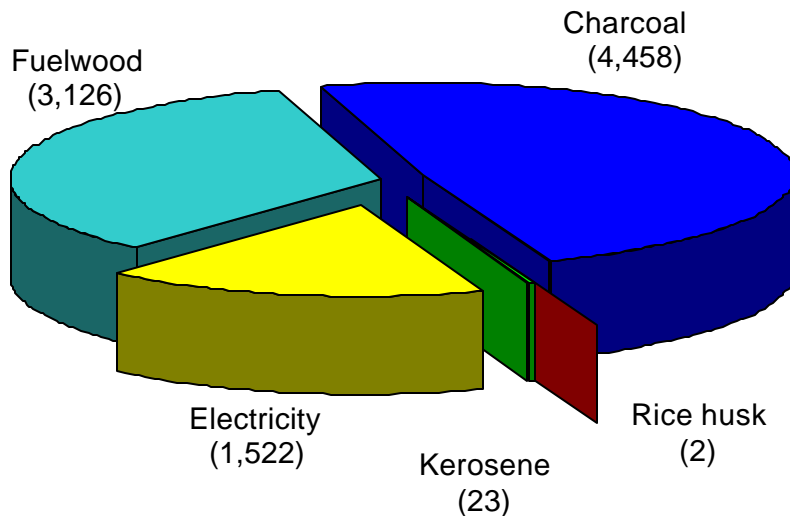

Fig. 16.2 Residential energy consumption by fuel in ktoe, (DEDP, 1994)

Traditional fuels supplied 65% of the total household energy requirement in 1988 and the modern fuels supplied the remaining 35%. Wood and charcoal are mainly consumed for cooking in sanitary and rural areas while LPG is mostly consumed in Greater Bangkok and municipal areas.

Historically, total demand for modern energy has been increasing both in urban and rural areas while the demand for traditional energy is declining. It is also to be noticed that households especially in the urban areas are replacing the traditional fuels by LPG though the rural households still depend on traditional fuels.
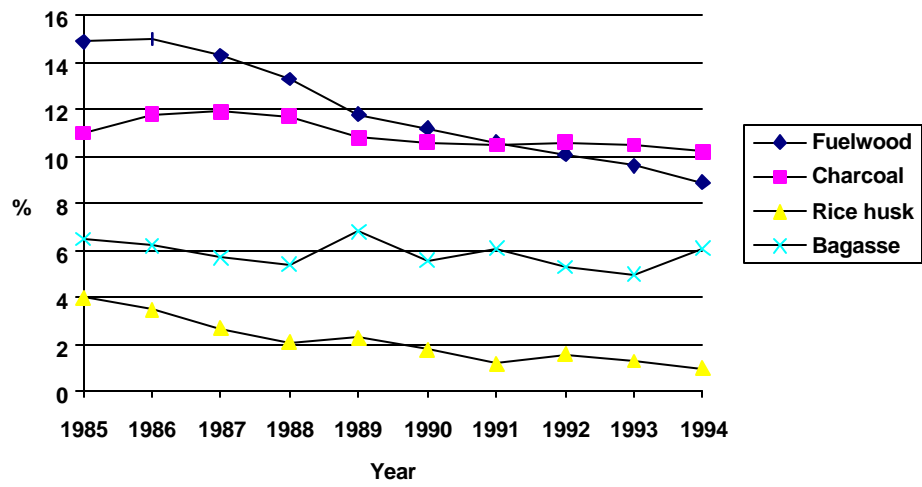
Fig. 16.3 Traditional energy consumption 1985-94 (DEDP, 1994)

17. VIETNAM

17.1. The Country

Vietnam has a total area of 3.30 Mha, extending 1,650 km N to S and 600 km E to W. Its total coastline on the South China Sea, the Gulf of Siam and Tonkin stretches 2,309 km. Vietnam has about 3,818 km of international border, which it shares with China (1281 km), Cambodia (982 km) and Laos (1,555 km).

Most of the northern part of Vietnam is mountainous, particularly the northern and northwestern sections. The lowlands consist of the Red River Delta and the coastal plains which extend northeast and south from the delta. South Vietnam is divided into four topographical regions. The lower third of the country is dominated by the estuary of the Mekong River system, a low and marshy flatland. Immediately north and east of Ho Chi Minh City, the topography becomes more varied with upland forests and rugged terrain. Central Vietnam is divided into a narrow coastal strip and a broad plateau separated from the coastal lowlands by the Annamite chain. The country also includes six islands and 14 mountain ranges. The principal river systems are the Red River in the north and the Mekong in the south.

17.2. Population and Land Use

The population of Vietnam was estimated in 1990 at 66.2 million. It is expected to reach 80 million by the year 2000. The annual growth rate is estimated at 2.0% on the basis of an annual birth rate of 31.2 per 1,000. The population is concentrated in the Red River Delta in the north and the Mekong River Delta in the south where densities approach 800 per km^2. The overall density of population was 219 per km^2 in 1993. The urban component of the population is 20% and the average income per capita is US$ 200 per capita. Average household size in Vietnam is 4.8, and 4.9 and 5.1 for rural and urban households respectively.

Table 17.1 Population and land use data

	Unit	1987	1988	1989	1990	1991	1992	1993
Total population	'000	62,510	63,856	65,246	66,689	68,188	69,737	71,324
Agricultural	'000	39,193	39,580	39,973	40,384	40,815	41,256	41,690
Total land	'000 ha	32,549	32,549	32,549	32,549	32,549	32,549	32,549
Arable + permanent crops	'000 ha	6,387	6,380	6,380	6,384	6,425	6,697	6,700
Irrigated land	'000 ha	1,800	1,820	1,830	1,840	1,850	1,860	1,860
Forest + woodland	'000 ha	9,769	9,600	9,500	9,395	9,617	9,650	9,650
Fuelwood Production*	'000m^3	25,572	26,130	16,694	27,262	27,832	28,405	28,984

Source: Country Tables, FAO Rome (1995)   **Includes wood converted to charcoal*

About 30% of the total land area is under forest cover. Another 21% of the total land area is under permanent crops and 6% is irrigated. The details of land cover categories of Vietnam are given in Table 17.2.

Table 17.2 The extent of different land cover types in Vietnam, 1985-86; 1992-93

Land cover category	Area in 1985-86		Area in 1992-93	
	(km^2)	(%)	(km^2)	(%)
Evergreen forest	84,930	26.1	80,303	24.7
Deciduous forest	14,933	4.6	11,349	3.5
Mangrove forest	1,307	0.4	1,150	0.4
Marshes	8,779	2.7	6,039	1.9
Scrub land	145,247	44.6	162,841	50.1
Agriculture	56,349	17.3	60,887	18.7
Water bodies	1,957	0.7	1,393	0.4
No data available	11,835	3.6	1,278	0.4
Total	325,336	100.0	325240	100

Source: Land Cover Assessment and Monitoring, Volume 5-A, UNEP Environment Assessment Program for Asia and the Pacific, Bangkok (1995)

17.3. Economy

The economic development of Vietnam during the period 1975 to 1990 can be reviewed in two phases. The first phase took place from 1976 to 1985 after the national reunification had centralized planning and subsidization mechanisms with the two five year plans of 1976-1980 and 1981-1985. In the second phase, from 1986 to 1990, there was a shift from the centralized system to a market oriented economy with macro adjustments. The Gross Social Product (GSP) for the 1986 to 1990 period is given in Table 17.3.

Table 17.3. Gross Social Product (GSP) of Vietnam (billion dong at constant 1982 prices)

Year	Industry	Agriculture	Transport	Service	Other	Total
1986	156.5	134.2	6.9	33.0	2.8	333.4
1987	169.4	137.1	7.6	34.3	2.8	351.3
1988	184.1	142.7	7.9	36.6	3.0	374.2
1989	180.6	152.8	7.3	37.7	3.0	381.5
1990	188.5	155.0	7.7	38.5	3.0	392.7
	Average growth rate during 1985-1990 (% per year)					
	4.9	5.3	3.5	3.7	-5.1	4.8

Source: Sectoral Energy Demand Analysis and Long Term Demand Forecasting, Cao Quoc Hung (1992)

17.4. Energy Situation

Vietnam is a relatively small producer and consumer of energy. The country, however, has large energy reserves, consisting of extensive coal deposits in Quang Ninh province in the north-east and the Bach Ho off shore gas field in the south east coast and a small gas field in the northern Thai Binh province. It also includes extensive peat deposits in Minh Hai province in the south, small peat deposits near Hanoi and considerable and widespread hydropower sources and biomass.

Table 17.4. Energy production and consumption data

Primary energy production	Unit	1989	1990	1991	1992
Solid fuels	ktoe	2,677	3,239	3,030	3,354
Liquid fuels	ktoe	1,487	2,695	3,955	5,489
Gaseous fuels	ktoe	17	3	2	2
Electricity	ktoe	326	462	486	507
Total conventional production	ktoe	4,507	6,398	7,474	9,353
Total consumption	ktoe	5,055	6,413	5,526	5,852
Per capita consumption	kgoe/capita	77	96	81	84
Fuelwood production	'000 m^3	23,645	24,147	24,652	25,160
	ktoe*	5,414	5,529	5,645	5,761

*Converted using 1 m^3 of wood = 0.23 toe

Source: 1992 Energy Statistics Yearbook, United Nations, New York (1994)

The per capita energy consumption, particularly of conventional energy sources, is one of the lowest in the world. Biomass fuels such as fuelwood and agricultural residues are the major source of energy used by the vast majority of the rural and semi urban population. People in urban areas also use electricity and coal. Coal is also the predominant fuel in the industrial sector.

Table 17.5 Energy consumption by sources and sectors 1990. (PJ/y)

Energy source	Industry	Agriculture	Construction	Transport	Domestic	Others	Total	In %
Conventional	87.5	12.3	75.9	25.8	19.3	29.8	250.5	26.0
Coal	38.9	*	67.0	*	9.5	13.5	128.8	13.4
Oil	41.4	10.7	5.8	25.6	5.1	13.9	102.4	10.6
Gas	1.0	0.0	0.0	0.0	0.0	0.0	1.0	0.1
Electricity	6.2	1.6	3.1	0.1	4.8	2.3	18.2	1.9
Traditional	89.8	-	3.2	0.0	620.4	-	713.4	74.0
Fuelwood	39.0	**	3.2	0.0	284.3	**	326.4	33.9
Charcoal	***	***	***	0.0	1.3	***	1.4	0.1
Residues	50.8	**	**	0.0	334.8	**	385.6	40.0
Total	177.3	12.3	79.1	25.8	639.7	29.8	963.9	100

*   included in "Other"   **   included in "Industry"   ***   not known

Source: Fuelwood and Energy Sectoral Review: Vietnam, Ministry of Forestry, Socialist Republic of Vietnam, Regional Wood Energy Development Programme, Food and Agriculture Organization, Bangkok (1992)

Traditional fuels such as fuelwood, crop residues and animal dung are mainly used for cooking in rural households. According to surveys carried out in different rural areas in 1990, traditional energy has a share of 66% in the total final energy consumption.

Table 17.6 Role of traditional energy in Vietnam-1990.

Year	Total primary consumption (ktoe)	Total final consumption (ktoe)	Total traditional consumption (ktoe)	Share of traditional in final consumption
1985	11,569	10,052	6,733	67.0%
1986	12,126	10,447	6,898	66.0%
1987	12,967	11,230	7,247	64.5%
1988	12,727	10,621	7,169	67.5%
1989	12,900	10,623	7,432	70.0%
1990	14,138	11,479	7,633	66.5%

Source: Sectoral Energy Demand Analysis and Long Term Demand Forecasting, Cao Quoc Hung (1992)

A major portion of the fuelwood is cut from forests and sold through the market. One third of such fuelwood is used for cooking purposes. The various types of fuels used, their calorific value as well as the end use devices employed and their efficiencies are given in Table 17.7

Table 17.7 Energy content of fuels and end use efficiencies of devices in use.

Type of fuel	Net calorific value (kcal/kg)	Moisture content (%)	End use device	Efficiency (%)
Fuelwood	3200-4000	8-10	Trivet	8-15
Hazelnut coal	2210	30-35	Nut coal stove	25-27
Kerosene	8000	-	Kerosene stove	40-45
Rice husk	3200-3400	9-11	Rice husk stove	12
Electricity	-	-	Electric stove	60

Source: Fuelwood and Energy Sectoral Review: Vietnam, Ministry of Forestry, Socialist Republic of Vietnam, Regional Wood Energy Development Programme, Food and Agriculture Organization, Bangkok (1992)

The majority of energy used for cooking by urban households and commercial enterprises is provided by traditional energy sources, mainly fuelwood. Coal, kerosene and electricity are also used in households.
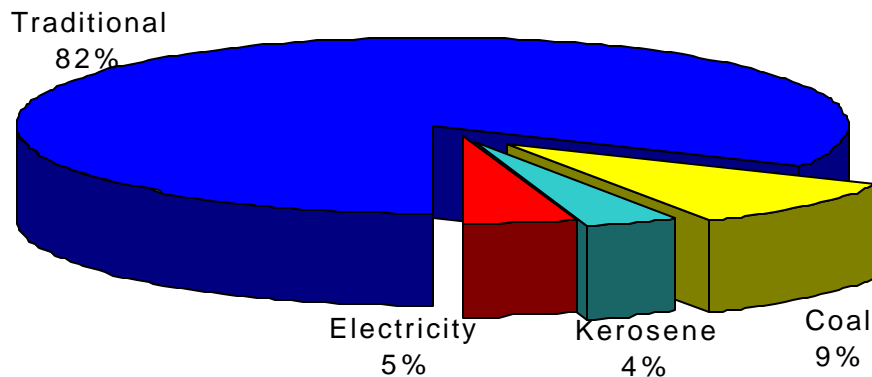

Fig. 17.1 Structure of energy consumption in urban cooking, 1990

About 76% of the rural energy is consumed by households, 95% of which is used for cooking. The remaining is consumed in village industries (19%), the service sector (3%), pumping and tilling (2%) and transport (0.5%)

Table 17.8 Structure of rural energy demand (fuels used in 1989)

	Type	Share (%)
Fuel type	Coal	34.3
	Oil	3.2
	Electricity	7.6
	Fuelwood	27.8
	Crop residue	27.2
	Total	100.0
End use sector	Household	76.0
	Service	2.9
	Village Industries	18.9
	Pumping & Tilling	1.9
	Transport	0.5
	Total	100.0

Source: Fuelwood and Energy Sectoral Review: Vietnam, Ministry of Forestry, Socialist Republic of Vietnam, Wood Energy Development Programme, Food and Agriculture Organization, Bangkok (FAO, 1992)

In 1986, about 31.7 million tons of biomass (expressed in wood equivalent or WE) were used as fuel. In addition to this, some 4.4 million WE were required for pig feed preparation. In Vietnam, it is customary to cook almost all pig feed which requires considerable amounts of fuel, often more than for domestic cooking. The composition of the total amount of 35.6 million tons wood equivalent consumed in 1986 is given in Table 17.9.

Table 17.9 Structure of fuel use in the domestic sector, 1986

Source	Mt WE		%	
Fuelwood	27.2		75. 0	
Natural forests and plantations		19.0		53. 3
Home gardens and scattered trees		7.2		20. 2
Sawdust and other wood waste		0.5		1. 5
Residues	5.6		15. 5	
Agricultural residues		4. 7		13. 2
Rice husk		0. 8		2. 3
Conventional	2.8		7. 8	
Electricity		0. 4		1. 0
Kerosene		0. 5		1. 5
Coal dust		1. 9		5. 3
Total (including pig feed preparation)	35.6		98.3*	

*Percentages in this reference do not add up to 100 with 1.7% unspecified.

Source: Fuelwood and Energy Sectoral Review: Vietnam, Ministry of Forestry, Socialist Republic of Vietnam, Regional Wood Energy Development Programme, Food and Agriculture Organization, Bangkok (FAO, 1992)

It is not known which conversion factors were used nor how the conversions were made from fuels to wood or wood to fuels.

17.5. Energy Demand in the Non Domestic Sector

The non domestic sector including industry, agriculture and construction accounts for about 34% of the total energy consumption. In addition to the conventional energy sources, about 28% of traditional energy is also used. The industries utilizing traditional fuels can be subdivided into 6 groups.

- Food processing industries including bakeries, noodle making, restaurants, confectionery, fruit preservation, fish smoking and drying etc.

- Mineral based industries like brick making, roof tile making, lime burning, refractories, porcelain, pottery, ceramic liner stoves etc.

- Agro processing includes processing of sugarcane, tea leaf curing and drying, rubber smoking, copra and coconut oil production, tobacco curing and coffee drying.

- Textile based industries such as textile printing, yarn dyeing, silk yarn reeling, other yarn making.

- Other activities such as road construction, soap making, paper making, salt making and pig feed preparation.

- Metal based industries such as foundries, blacksmiths, and jewelry making.

Table 17.10 Fuel use in the non-domestic sector ('000 tons of wood equivalent, 1989)

Industry	Wood	Residues	Conventional	Total	%
Food processing	97	74	38	209	3
Agro processing	425	541	-	966	13
Mineral based industries	1,150	-	1,150	2,300	30
Other activities	52	-	15	67	1
Pig feed preparation	2,037	2,037	-	4,075	53
Total	3,760	2,653	1,203	7,616	100

Source: Fuelwood and Energy Sectoral Review: Vietnam, Ministry of Forestry, Socialist Republic of Vietnam, Wood Energy Development Programme, Food and Agriculture Organization, Bangkok (FAO, 1992)

17.6. Traditional Energy Resources

Out of the total land area of 33 Mha, about 57% or 19 Mha is classified as forest land. However only 9.3 Mha is estimated to have forest cover and about 9.6 Mha is deforested and subject to shifting cultivation and gathering fuelwood and woody biomass. Statistics give the total production and protection forest as 7.3 Mha.

From the total area of 5.5 Mha of natural forests annual sustainable production of 2.6 million tons is estimated. The 603,000 ha of productive plantation also supply a significant quantity of wood.

Assuming a fuelwood yield of 50% of mean annual increment and a density of 0.7 ton/m^3, these plantations could potentially provide 3.5 t/ha/yr, or a total of 2.2 million ton/yr.

Table 17.11 Land potential for supplying cooking fuels in the suburbs and the countryside

Type of land	Type of fuel	Area (ha)
Cultivated land	Crop residues	108,938
Forestry land	Fuelwood and residues	26,599
Existing forestry land	Fuelwood and residues	4,794
Reforestation land	Eucalyptus fuelwood and residues	3,916
Afforested waste land	Eucalyptus fuelwood and residues	17,889
Decentralized planted	Biomass	16,350
Forestry waste land	-	4,578
Total		156,465

Source: Sectoral Energy Demand in Vietnam, Regional Energy Development Programme, United Nations, Bangkok (REDP, 1992)

Another category of land, namely bare forest land, can supply about 0.5 ton/ha/y of fuelwood on a sustainable basis. This may provide about 4-4.5 million tons of fuelwood per year.

Wood residues available are saw dust, barks and wood from scattered trees in home gardens, agricultural lands, roadsides and canal banks and wood from perennial crops such as rubber trees and coconut palms. Non wood residues which are available include rice husks, rice straw, maize cobs, stalks and leaves.

Table 17.12 Estimated amount of wood residues generated in Vietnam

Type of residues	Amount generated ('000 tons)
Scattered trees	8,096
Forest industries	1,575
Other wood wastes	600
Perennial (rubber wood, palm etc.)	781
Total	11,052

Source: Fuelwood and Energy Sectoral Review: Vietnam, Ministry of Forestry, Socialist Republic of Vietnam, Wood Energy Development Programme, Food and Agriculture Organization, Bangkok (FAO, 1992)

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Appendix A: Measurements and Units

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Appendix A: Measurements and Units

Wood is widely used as an energy source in the RWEDP region. It can be classified as softwood or coniferous, and hardwood or non-coniferous. Since fuelwood is considered as a non economic commodity in many countries, it is often not accounted for in the energy balance nor has there been any standard for the measurement of quantity and quality.

In many of the RWEDP member countries, fuelwood is an important energy source, especially in the rural areas. In order to assess the quality of wood as an energy source, it is necessary to know the energy content or heating value. But, the complexity of assumptions, conventions and definitions used in the wood energy literature is likely to confuse anybody who doesn't have a deep understanding of these matters. Hence, an attempt is made here to analyze the factors relevant to the use of wood as an energy source.

A.1. Measurement of Fuelwood

Foresters and other experts who deal with wood frequently measure it by cubic meter. This is a solid meter cube of wood and is usually used with reference to commercial timber.

Fuelwood is usually measured by stacked cubic meter or stere (sometimes confusingly called a cubic meter). This is a stack of branches or split wood with a volume of one cubic meter. The actual amount of wood in a stacked cubic meter or stere will vary according to how closely it is packed.

A.2. Fuelwood Composition

Freshly cut fuelwood is bulky, having high moisture as well as volatile content. Most species of fuelwood are uniform in their elemental composition. Quantities of nitrogen, carbon, oxygen etc. contained in fuelwood can be estimated by the method of ultimate analysis. The relative amount of ash, fixed carbon and volatile matter in a solid fuel can be determined by proximate analysis.

A.3. Moisture Content of Fuelwood

Both the weight of wood and the amount of energy obtained when it is burned vary according to the amount of moisture it contains. Two methods are commonly used for specifying the moisture content. It is important to distinguish between these, especially when the moisture content is high.

- The "moisture content on a dry basis" expresses the amount of water in a sample as a proportion of the weight of the wood when it has been dried in an oven.

- The "moisture content on a wet basis" expresses the amount of water as a proportion of the weight of the wood and the water. Wood which has been allowed to dry out for a couple of months - usually referred to as air dry wood - has a moisture content of 16.6% on a wet basis or 20% on a dry basis. Newly cut or green wood with a moisture content of 60% on a wet basis has a moisture content of 150% on a dry basis.

A.4. Densities and Weights

The density of wood, that is its weight per unit of volume, varies widely between different wood species. The density of an air dry hardwood such as mahogany or ebony is around 1000 kg per solid cubic meter. A really lightweight wood such as balsa may have an air-dry density of as low as 160 kg per solid cubic meter. Very roughly, a stacked cubic meter or stere of fuelwood can be taken to weigh 200-300 kg.

Assuming that one stacked cubic meter of fuelwood weighs approximately 250 kg, and 1 kgoe is about 2.73 kg of fuelwood (ref. Table A.3), the conversion factor for toe can be calculated as 1 m^3 of fuelwood equivalent to 0.09 toe. This conversion factor was used for converting m^3 to toe in this report.

A.5. Calorific Values

The amount of useful heat which can be obtained from burning a given quantity of fuel is called the net calorific value. It is usually expressed in megajoules per kilogram (MJ/kg).

In the case of wood and other biomass fuels, the net calorific value varies enormously depending on the moisture content. The following are some net calorific values for wood at different moisture contents and a variety of other fuels.

Table A.1 Moisture content and corresponding net calorific value

1 kg oven dry wood	20 MJ
1 kg air dry wood (17% MC on wet basis)	15 MJ
1 kg green wood (60% MC on wet basis)	8 MJ
1 kg charcoal	30 MJ
1 kg air dry dung	11 MJ
1 liter kerosene (0.8 kg)	43 MJ

Source: "Energy for the People, A Dossier on Woodfuel in the Developing World", Commission of the European Communities (1988)

A.6. Comparison with Conventional Fuels

While fuelwood is the main source of energy in many developing countries, fossil fuels are likely to maintain their predominance in the conventional energy supplies in the developed regions. Many consumers may then be faced with a choice between a range of fossil fuels and fuelwood as an alternative or replacement energy source. The useful heat content approach (A.5. above) provides an equitable means of comparing fuels.

Table A.2 Net Calorific Value of main conventional fuels

Oil	42.8 MJ/kg
Coal	29.3 MJ/kg
Peat (35% MC)	12.6 MJ/kg
Natural gas	34.8 MJ/kg
Wood (30% MC)	11.4 MJ/kg

Source: Lyons et al, A Procedure for Estimating the Value of Forest Fuels, Biomass, Vol. 8, pp. 283-300 (1985)

Assuming that all fuels are burned completely under the same conditions, the relative useful heating values may be derived. The fuel equivalent ratio for wood, oil, coal, peat and natural gas calculated using theses values are given below.

Table A.3 Fuel equivalent ratio of various fuels

Fuel	30% MC wood (tons)	Oven dry wood (tons)
1 ton oil	3.90	2.73
1 ton coal	2.68	1.88
1 ton peat	1.11	0.78
1000 m3 natural gas	3.16	2.21

Source: Lyons et al, A Procedure for Estimating the Value of Forest Fuels, Biomass, Vol. 8, pp. 283-300 (1985)

These equivalents represent the energy actually recovered by burning the respective fuel and may thus be used to compare the usable heat costs for various energy sources.