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Explanatory notes

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Preface

The present publication consists of papers and results of case studies submitted to the Symposium on Development and Utilization of Biomass Energy Resources in Developing Countries, held by the United Nations International Development Organization (UNIDO) at Vienna from 11 to 14 December 1995. The objective of the Symposium was to facilitate a dialogue between technologists, technocrats, scientists, decision makers and potential donors, in order to promote and identify biomass energy technical assistance and investment projects. The Symposium was convened under the overall direction of A. Tcheknavorian-Asenbauer, Managing Director, Industrial Sectors and Environment Division of UNIDO.

Volume I of the publication presents the opening statement and keynote addresses of the Symposium, and includes 21 papers. Fourteen countries are represented thus giving a broad perspective on the development and utilization of biomass energy resources. The papers are organized into six parts, each dealing thematically with the topic of the Symposium. The last part summarizes the outcome of a round-table discussion held at the conclusion of the Symposium. The contents of each part are outlined below.

Part one, consisting of six papers, provides an overview of the development and utilization of biomass energy in the following six regions: Africa; Asia; Asia-Pacific; Central America; central Europe; and eastern Europe. Particular emphasis is given to identifying regional biomass energy resources, establishing the extent to which the resources are utilized and determining the technologies currently applied to the enhancement of biomass resources and their conversion into energy. The papers further discuss the policies and strategies governing, as well as the barriers limiting, the development and utilization of biomass energy resources.

Part two, consisting of six papers, deals with technologies for the enhancement and conversion of biomass resources. The first three papers focus on issues related to the enhancement of biomass energy resources. Problems associated with the lower energy density of biomass and its lower concentration relative to fossil fuels are discussed, and situations in which advanced technologies for the enhancement of biomass resources should be developed are identified. Those situations are then assessed from a pragmatic perspective on resource enhancement. Finally, technology options are critically reviewed.

The fourth paper examines the main existing and innovative technologies for converting biomass into electric power or heat. The status of conventional versus advanced technology in a few developing countries is reviewed. Finally, major technology options are covered in detail, and criteria for their effective application in developing countries are discussed. The next paper provides detailed coverage of two biomass conversion technologies: circulating fluidized-bed combustion and circulating fluidized-bed gasification, both designed and developed by Lurgi. In addition, criteria for the selection of either technology are discussed, and a procedure for transfer of the technologies to developing countries is proposed.

The last paper in the section deals with the issue of technology transfer. A new perspective on this complex process is presented, involving a systematic approach to establishing a complex technological capacity in a given field. A successful project in East Africa is described to support the arguments for the new perspective.

Part three, consisting of two papers, covers funding sources and mechanisms. The first paper examines the technologies and fuel risks that are unique to biomass energy projects, and summarizes the public financing sources and support that are available to assist in dealing with the unique risk profiles. The paper also presents potential strategies that the developer of a biomass project could apply in seeking the involvement of, and negotiating with, local governments and public financing agencies.

The second paper discusses financing hurdles and other problems facing biomass utilization in developing countries. In order to promote market penetration by technologies designed to achieve widespread and efficient use of biomass, the paper emphasizes the need for intervention by Governments or by the Global Environment Facility. To accelerate the flow of private capital, the paper proposes joint implementation of biomass technology projects by industrialized and developing countries.

Part four, consisting of four papers, is concerned with the environmental economics of biomass energy utilization. The first paper focuses on the environmental, social and economic benefits of sustainable development and utilization of biomass energy. The second paper gives a perspective on the role of biomass energy in the ecosystem, and discusses the technical, institutional and social barriers that must be overcome.

The third paper presents a cost comparison between biomass and coal as feedstocks for production of electricity and liquid fuels using advanced conversion technologies in developing countries. The last paper looks at the external costs of electricity generation–costs not included in the market price mechanism. Those costs are divided into two categories: environmental external costs; and non-environmental external costs. The paper details environmental and non-environmental externalities, and discusses various strategies for internalization of external costs of conventional forms of energy, including emission taxes and tradable emission permits.

Part five contains three special papers. The first presents a historical overview of fuel oil from Jatropha plants in Africa, focusing on the approach used to overcome problems during the implementation of a pilot project in Mali. In addition to information on the use of plant oil as fuel, the paper provides a perspective on the positive environmental, social and economic effects of such use, and describes a technology transfer approach that encourages the local production of the required equipment, and concentrates on training and dissemination of the relevant know-how. The second paper explores the potential for the utilization of oil crops as an energy source, focusing on the use of untreated vegetable oils, particularly rapeseed oil, for that purpose. It then reviews the process feasibility aspects and future possibilities for the use of vegetable oils. The last paper reviews the current and future role of biomass energy in the pulp and paper industry. It further considers the likelihood of the pulp and paper industry serving as an important early market for advanced biomass-based co-generation technology.

Part six provides a summary report on the consensus and conclusions reached during a round-table discussion, held at the conclusion of the Symposium, on the need for, and identification of, technical and investment projects in the field of biomass energy.

Volume II of the publication presents the results of three UNIDO-sponsored case studies conducted in Brazil, the Philippines and Romania. The results were presented at the Symposium.

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Part one

Biomass energy potential in Brazil Country study*

Abstract

The present paper was prepared as a country study about the biomass potential for energy production in Brazil. Information and analysis of the most relevant biomass energy sources and their potential are presented in six chapters. Ethanol fuel, sugar-cane bagasse, charcoal, vegetable oil, firewood and other biomass-derived fuels are the objects of a historical review, in addition to the presentation of state-of-the-art technologies, economic analysis and discussion of relevant social and environmental issues related to their production and use. Wherever possible, an evaluation, from the available sources of information and based on the author's knowledge, is performed to access future perspectives of each biomass energy source.

Brazil is a country where more than half of the energy consumed is provided from renewable sources of energy, and biomass provides 28 per cent of the primary energy consumption. Its large extension, almost all located in the tropical and rainy region, provides an excellent site for large-scale biomass production, which is a necessity if biomass is to be used to supply a significant part of future energy demand. Even so, deforestation has occurred and is occurring in the country, and the issue is discussed and explained as mainly the result of non-energy causes or the use of old and outdated technologies for energy production.

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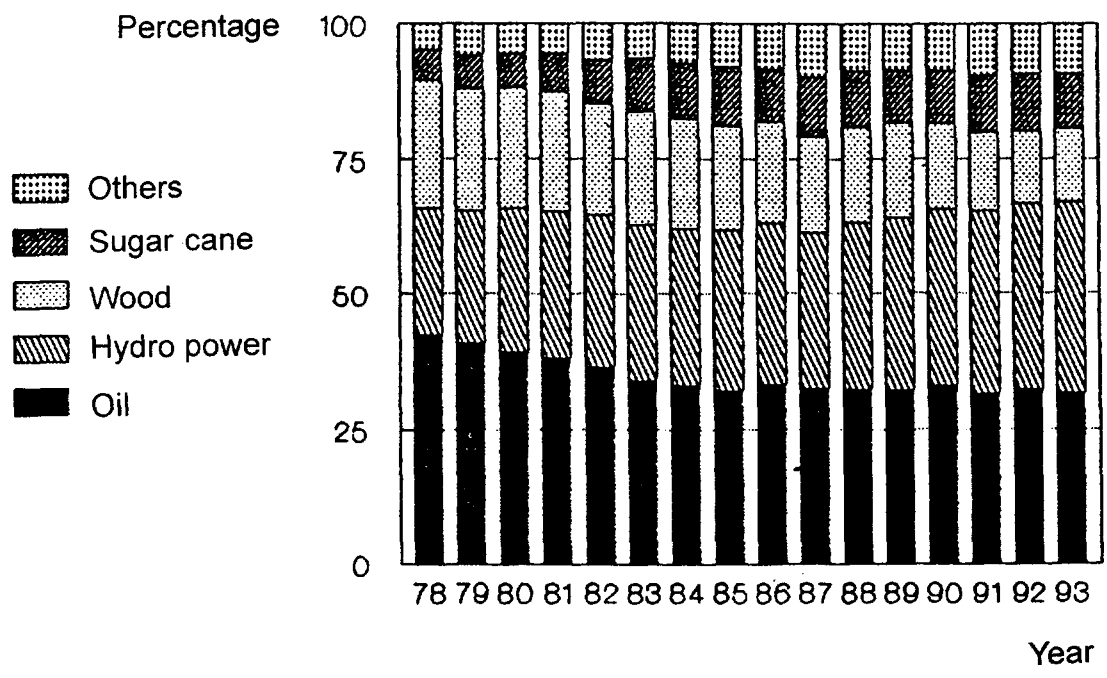
*Prepared by Biomass Users Network–Brazil Regional Office, São Paulo, Brazil. Principal investigator José Moreira.

I. CONTEXT AND FRAMEWORK OF THE STUDY

As in most developing countries, and in contrast to fuel substitution trends in developed countries [1], biomass is still an important part of the primary energy mix in Brazil, being surpassed only by hydropower. In recent years, there has been a growing interest in modern uses of biomass, including biomass-based electricity generation in the United Nations of America [2] and district heating in Austria and Denmark [3], the ethanol programme in Brazil [4] and the gasohol programme in the United States [2], to mention a few. Recent scenarios are much more optimistic regarding the contribution of biomass to the primary energy mix in the near future [5-8].

A recent publication [9] shows a primary energy profile (see figure I.1) in which hydropower accounts for 43.5 per cent, oil 20.7 per cent and biomass 28.3 per cent. The biomass contribution to the energy mix is not quite accurate, since it includes biomass used in non-commercial applications. Nevertheless, as reflected in figure I.2, its commercial use for the production of charcoal, ethanol and thermal energy is higher than its non-commercial use, which limits the degree of uncertainty. Figure I must be examined carefully, since primary hydropower is compared with other energy sources on the basis of the average thermal efficiency (27.5 per cent) of the installed thermoelectric plants in Brazil [9]. On that basis, 1 kilowatt (kW) of electricity is accounted, in the primary energy mix, as equivalent to 3.63 kW thermal or alternatively, 1 kW of electricity is equivalent to 3,132 kilocalories.

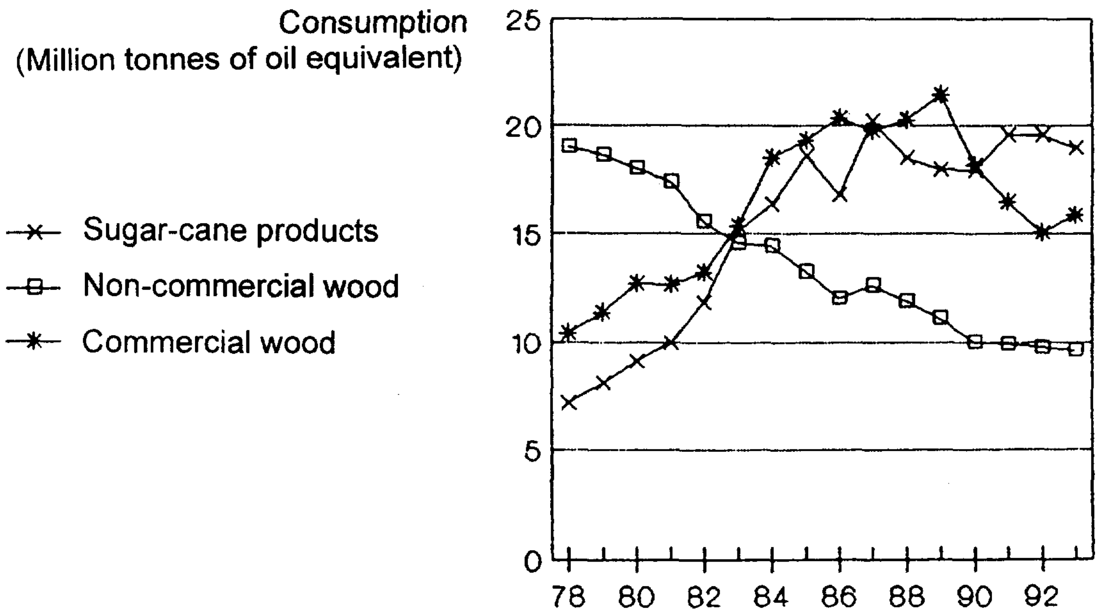
Figure I.1. Primary energy consumption in Brazil



Source: BEN/1994 and MME/Brazil (further details on sources provided by author on request).

Note: Total consumption in 1993: 190.4 million tonnes of oil equivalent.

Figure I.2. Consumption of biomass fuels in Brazil



Source: BEN/1994 and MME/Brazil (further details on sources provided by author on request).

The pig-iron and steel industry of Brazil makes extensive use of charcoal in small and medium-sized ovens. In 1993, of the 25.2 million tonnes of steel produced, 4.3 million tonnes were obtained through the use of charcoal. Its use is common, since it is possible to obtain a high-quality iron (almost sulphur-free). The major drawback is its cost, which is no longer as competitive with coal as it was when natural forests could be cut down and the wood processed into charcoal in low-technology brick ovens.

Concern about deforestation was the basis for legislation requiring that almost all the wood used to produce charcoal must come from planted forests. Another reason for the rising costs of charcoal is that most of the natural forests located near the pig-iron industries in the major pig-iron- and steel-producing State of Minas Gerais were exhausted or protected, and charcoal had to be produced at distant sites and transported at a high cost to its final destination.

Sugar-cane bagasse is largely available as a result of traditional sugar production, dating from the sixteenth century and based on sugar cane. The ethanol programme PROALCOOL, started in 1975 for the purpose of using alcohol as a fuel for automobiles, led to a huge expansion of such production. Total sugar-cane plantation acreage jumped from 1.5 million hectares in 1970, to 4.3 million hectares in 1990. Assuming an average yield of nearly 60 tonnes of sugar cane per hectare, approximately 260 million tonnes can be produced. Approximately 28 per cent of that total is obtained as a by-product (bagasse) of the ethanol and sugar processing industries, with a moisture content of 50 per cent. Total dry biomass is 32 million tonnes. The total bagasse energy content is computed in accordance with the official energy balance [9] as 127.6 x 10^9 megacalories, or 12.3 x 10^6 tonnes of oil equivalent (toe), equivalent to 20.6 per cent of the energy content of the oil consumed in the country, or 39.3 per cent of the total oil production of the country in 1993. Nearly 90 per cent of this energy is consumed at the sugar and ethanol mills for their own operation.

Non-commercial biomass is mainly used in rural areas or in small cities. In the residential sector, 25.4 x 10^6 tonnes of firewood is consumed, representing 30.6 per cent (7.4 x 10^6 toe) of total firewood consumption, and most of it is non-commercial. The preferred fuel for residential cooking is liquefied petroleum gas (LPG), which is distributed to almost all regions of the country in containers with a net weight of 13 kilograms (kg). Total residential consumption of LPG is 5.3 x 10^6 toe. A few consumers in São Paulo and Rio de Janeiro have access to a gas network which delivers producer gas from coke or natural gas, supplying 0.13 x 10^6 toe for the residential sector. Typical use of LPG is one vessel per family per month. Assuming four persons per family, this means that 33.9 million families, representing almost 80 per cent of the population of the country, rely on LPG for cooking.

Another evaluation can be made, assuming that cooking with LPG is 10 times more efficient than with firewood [4]. Based on this assumption, a comparison of 7.5 x 10^6 toe of firewood x 0.1 = 0.75 x 10^6 toe of LPG with the actual consumption of 5.3 x 10 ^{6}toe of LPG again shows that approximately 90 per cent of the population uses LPG. Thus, since the residential use of wildfowl is small, the density of the rural population low and the rate of growth of the vegetation high [10], such use does not arouse concern about deforestation.

All major energy sources are controlled by government enterprises, such as PETROBRAS, which holds the monopoly for oil and gas exploration, exploitation and transportation. In 1993, ELETROBRAS and its subsidiaries at the federal level and the State-owned electricity companies accounted for 237 terawatt-hours (TWh), or 94.4 per cent, of a total production of 251 TWh [9]. Unlike the major energy sources, biomass is managed by private entrepreneurs. In the case of ethanol, the enterprises are required to deliver their products directly to PETROBRAS, which is responsible for mixing it with gasoline and forwarding the 95 per cent pure ethanol to distribution companies and to the end-users.

Several examples of the use of biomass as a source of energy are discussed in the following chapters. A historical description of the problems associated with the use of biomass resources is given, technological, environmental, economic and social issues are reviewed, and the future prospects for biomass energy are considered. Each secondary form of biomass energy is analysed so as to quantify its relative importance in the energy mix today and in the future. The main objective is to demonstrate that biomass in many tropical countries is a significant source of energy, and may be even more important in the future, if global concern about social and environmental issues increases.

The discussion of ethanol fuel is followed by the chapter on sugar-cane bagasse, which describes the sugar-cane crop and industrial processing, and emphasizes the possibility of simultaneous production of liquid fuels and electricity. Such an optimized use of biomass would enable a significant amount of energy to be produced and increased competitiveness with oil to be achieved.

Chapter IV deals with charcoal, which is traditionally prepared using low- and medium-level technologies. The future prospects for charcoal depend heavily on the use of advanced technologies to recover liquid and gas products that are usually lost, bringing increased competitiveness with coal. Chapter V describes the vegetable oil potential as an alternative to diesel oil. Although vegetable oil for energy use currently has a small market, the conditions required to increase its competitiveness with diesel oil are discussed, taking into account social and environmental issues. Chapter VI deals with firewood. In many countries, firewood is obtained from natural vegetation and through deforestation. Since deforestation in Brazil is immediately associated with the destruction of the Amazon rainforest, the major reasons for deforestation in the Amazon are discussed in detail in this section. The objective is to show that tropical forest destruction has very little to do with the use of firewood, but is strongly related to cattle-ranching, slash-and-burn agriculture and lumbering. Finally, in Chapter VII, other secondary biomass energy processes and sources are discussed, including anaerobic fermentation, thermochemical gasification and briquetting. Conclusions are presented in Chapter VIII.

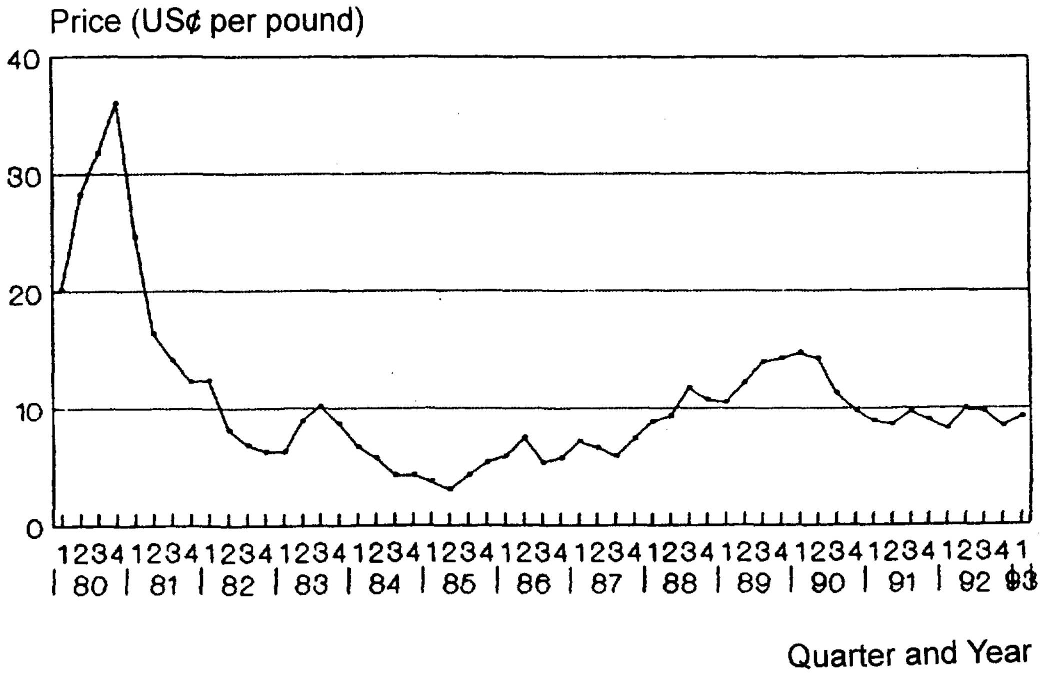
II. ETHANOL FUEL

A. Historical background

Ethanol has been used as an Otto engine fuel in significant amounts since 1975, in an effort to save foreign currencies drained by oil imports at a rate that the nation could not sustain.

At first, the plan (PROALCOOL) focused on providing ethanol to be blended with gasoline, to produce a fuel with a 20 per cent ethanol content. The plan, however, foresaw a wider use of ethanol in automobiles running on pure alcohol instead of gasoline. By 1984, just five years after the full implementation of the plan, ethanol-fuelled cars accounted for 94.4 per cent of total automobile production (see figure II.1).

Figure II.1. Trend in the price of demerara sugar (New York)

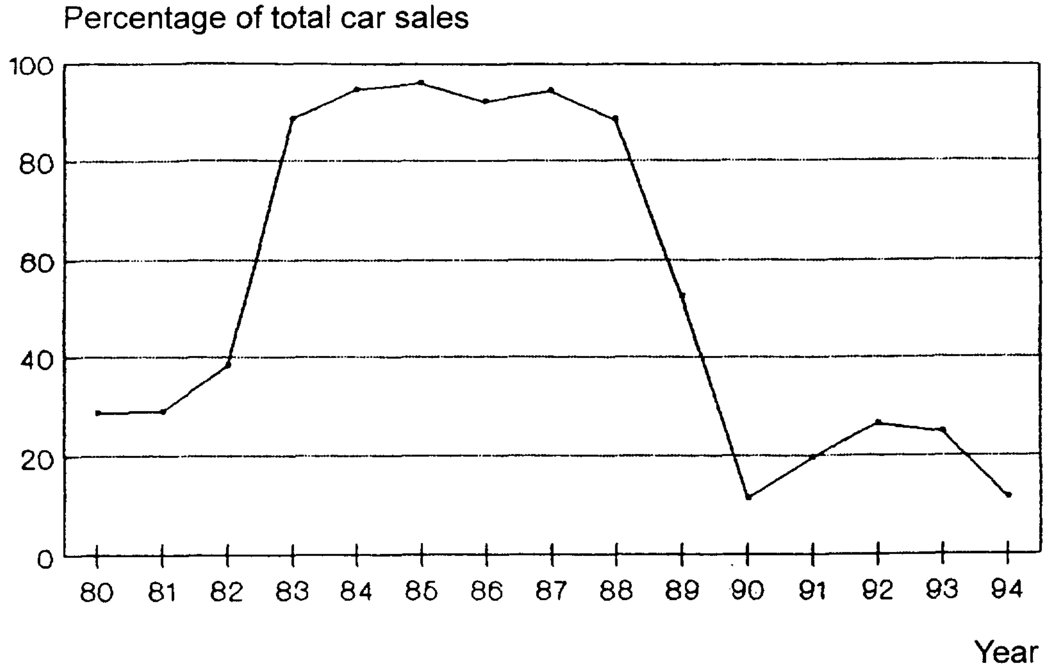


Source: *DATAGRO*, No. 18 (1993), p. 6.

Note: 1 pound = 0.454 kg.

It was in mid-1988 that the ethanol era began to show the first signs of decline. There was a reduction in international tension, resulting from the changes in the former Union of Soviet Socialist Republics and eastern Europe. Consequently, oil prices started to decline steadily. In Brazil, sugar seemed to become more attractive than ethanol to producers [11, 12], even though sugar prices on international markets dropped somewhat after 1989 (see figure II.1). Simultaneously, the sale of new 100 per cent ethanol-powered cars continued at 89.4 per cent of total sales in 1988 (see figure II.2). As a result, there were isolated shortages of ethanol, and customers began to distrust automobiles using the alternative fuel. Thus, in 1989, after a major mid-year alcohol shortage, sales of new 100 per cent ethanol-powered cars dropped to 51 per cent of the total.

Figure II.2. Sales of ethanol-powered cars in Brazil



Source: *DATAGRO*, No. 8 (1995), p. 12.

By 1990, new government regulations for entry-level popular cars had introduced incentives, including a substantial tax cut. The aim was to stimulate automobile production, which was stagnating at 700,000 vehicles per year, compared with a peak of almost 1.1 million a decade earlier. The engine size of the new class of automobiles was limited to a 1-litre displacement. All automobile manufacturers in Brazil (Fiat, Ford, General Motors (GM) and Volkswagen) therefore had to commercialize such engines within 18 months. Time constraints imposed the use of engines that were already available at their factories worldwide, for example, gasoline-based engines. It was out of the question to cast special cylinder heads with combustion chambers designed to obtain high compression ratios needed for an efficient ethanol engine. As a result, 1-litre entry-level ethanol versions had to be simply postponed indefinitely [13].

By 1993, the low-tax entry-level class was enlarged to include 1.6-litre models, and further tax incentives were provided. Yet, entry-level models (or popular cars) still did not exist in ethanol versions, except for the low-selling Volkswagen Bug. Popular cars, however, accounted for 50 per cent of the 1.4 million cars produced in 1994.

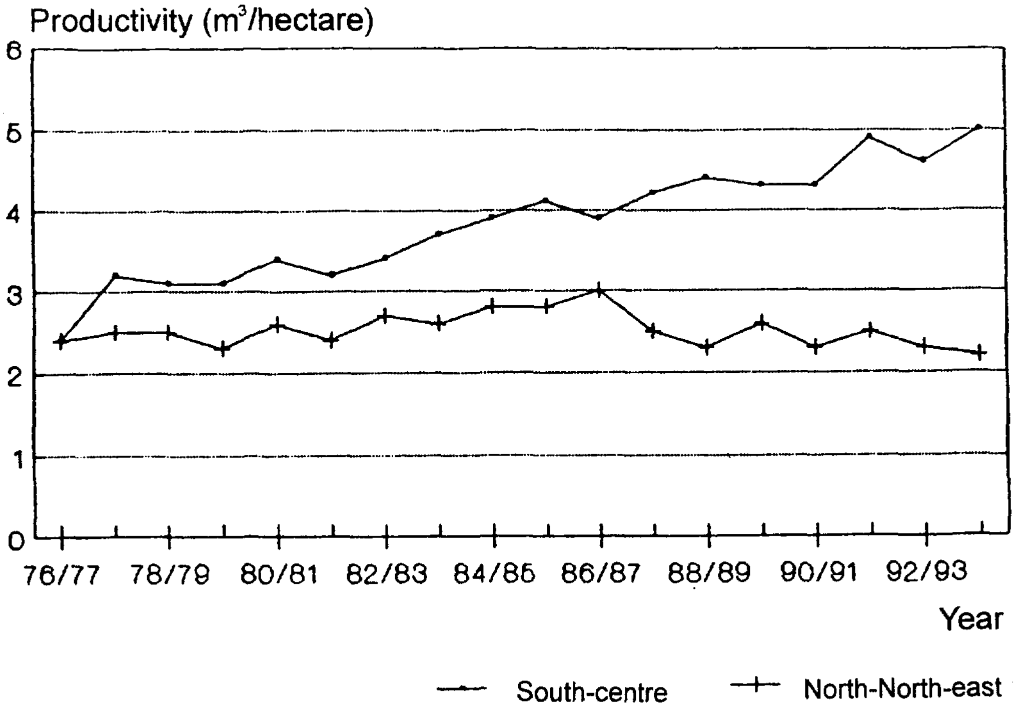
Another obstacle for pure-ethanol-fuelled cars was the introduction of electronic fuel injection, starting in 1989. By September 1991, GM DO BRASIL had introduced fuel-injection cars, available in both gasoline and ethanol versions [13]. Customers discovered the benefits of a far better way of mixing ethanol and air, although the systems were not yet quite ideal. By 1994, GM had marketed the 2-litre alcohol-fuelled engine, with multipoint-injection, and it did not display any of the problems formerly associated with alcohol-fuelled cars. It works flawlessly, from cold starts on winter mornings to starting on the hottest summer days, and is very powerful, producing 130 horse power net from a 122-cubic inch* engine. This makes it by far the world's most powerful four-cylinder engine of its size and type [13]. In 1995, Volkswagen followed up with a multipoint 2-litre ethanol injection engine. Such technical improvements, however, have not yet restored consumer confidence in alcohol-fuelled vehicles.

B. Technological improvements

1. Production

As shown in Figure II.3, between 1976 and 1994, there was a significant change in the pattern of production of ethanol from sugar cane, which increased from 2,400 to 5,000 litres per hectare in the south/centre region of the country, while remaining almost constant at 2,400 litres of ethanol per hectare in the northeast** region [14]. Average annual productivity varies from region to region and is higher in the State of São Paulo, with a yield of 5,847 litres per hectare in 1985 and 1986 [15], and 7,902 litres per hectare from 1992 to 1994 [16]. It is worthwhile to note that agricultural and industrial yields were as high as 7,045 litres per hectare for the 12 most productive sugar-mills in the State, and responsible for 25 per cent of total Brazilian production already in 1985 and 1986 [15] (see table II.1).

Figure II.3. Agro-industrial productivity of ethanol from sugar cane



Source: *DATAGRO*, No. 24 (1993), p. 6.

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*1 cubic inch = 16.4 cubic centimetres.

**The north-east has been responsible for less than 10 per cent of total Brazilian ethanol production since 1983.

Table II.1. Agricultural and industrial average productivities from sugar-mills in the State of São Paulo

Group	Number of mills	Relative contribution to total cane (percentage)	Average industrial yield (litres per tonne)	Average agricultural yield (tonnes per hectare)	Alcohol (litres per hectare)	Total alcohol produced	
						Cubic metres	Percentage (volume)
1	12	25.4	78.9	89.3	7,045.8	1,440,952	24.8
2	10	19.8	80.1	73.2	5,863.3	1,014,494	17.4
3	8	10.2	69.9	86.2	5,939.2	585,565	10.1
4	19	17.9	73.6	70.7	5,203.5	876,916	15.1
5	14	8.1	71.6	70.9	5,076.4	398,486	6.8
6	24	8.5	67.7	87.3	5,910.2	698,092	12.0
7	34	6.8	68.5	72.8	4,986.8	592,812	10.2
8	12	3.2	62.3	58.2	3,625.9	207,757	3.6
Total	**133**	**100.00**	-	-	-	**5,815,074**	**100.0**

Source: *Conselho Estadual de Energia, Pesquisa de Mercado do Álcool de Cana Produzido no Estado de São Paulo* (São Paulo, February 1987).

As a result of the productivity increase, ethanol production costs declined continuously at an annual rate of 3.7 per cent per year from 1979 to 1988 [17]. Significant opportunities for further productivity improvements exist. Figure II.4 displays the yield of sucrose (or total reducible sugar) in the sugar and ethanol processing mills in Brazil between 1984 and 1995, when no new land was added for sugar crops. The increment is mainly due to the use of new sugar-cane varieties and will continue, since a significant share of the varieties used are by far not the best available (see table II.2).

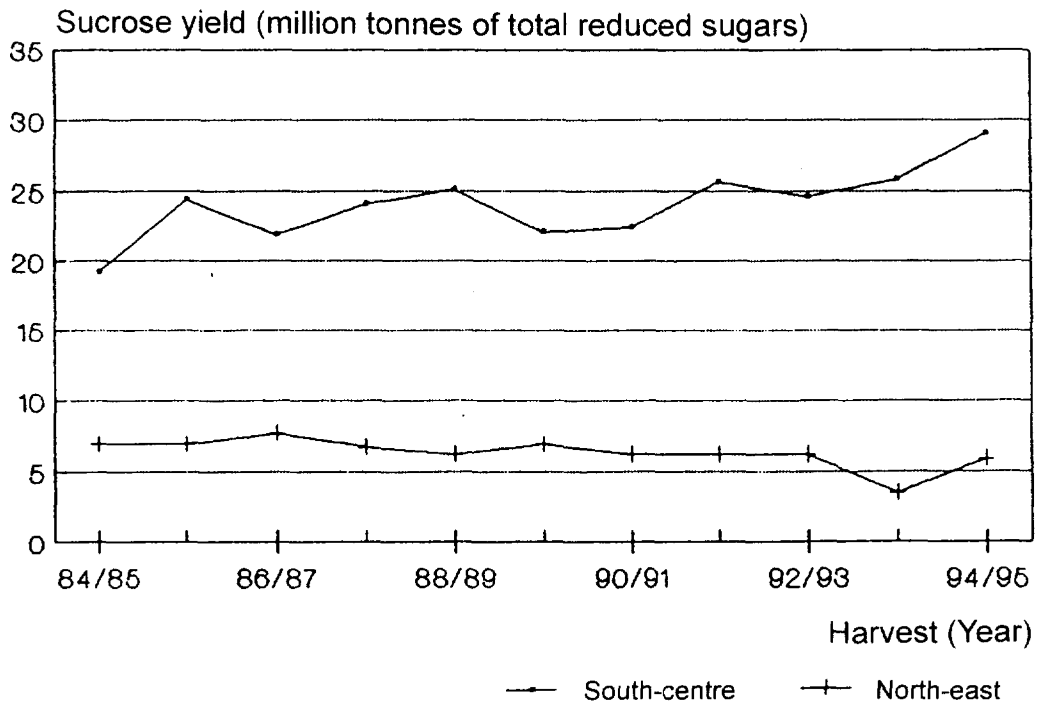
Table II.3 [4] shows the effect of various parameters on the production cost of ethanol. Proper variety selection and handling can reduce production costs by 9.8 per cent. The agricultural phase (involving lime application, the use of liquid fertilizers and sludge, weed removal, transportation and operational planning) offers opportunities to reduce the production costs of ethanol by a further 9.3 per cent. Better industrial processing can reduce costs by an additional 6.4 per cent. All together, the cost of ethanol production can be reduced by 23.1 per cent.

2. New ethanol blend

Another important technological advance has been the production and large-scale use of a new alternative fuel for Otto cycle engines. Consumer pressure arising from the 1989 ethanol shortage spurred efforts to find a substitute for ethanol. Since most of the ethanol used for ethanol-fuelled automobiles was hydrated (approximately 8 million m^3 per year as 95.6 per cent pure ethanol), the practical approach was to search for a fuel that could replace hydrated ethanol without adaptation or retuning of the existing engines. Methanol was available at international market prices below \$100 per m^3,* and its use was economically attractive.

*Methanol has been commercialized on the international market at prices which fluctuate considerably. In 1989, it was quoted at below 100 United States dollars (\$) per cubic metre (m^3), jumped to \$475 per m^3 in the second quarter of 1994, and was approaching \$130 per m^3 at the end of the first quarter of 1995 [18].

Figure II.4. Yield of sucrose in Brazilian industry



Source: DATAGRO, No. 7 (1995), p. 5.

Table II.2. Potential evolution of agricultural ethanol yield as a result of better selection of sugar-cane varieties in Copersucar mills

Sugar-cane variety	Planted area, 1987/88 (percentage)	Planted area, future extension (percentage)	Amount of sucrose (tonnes per hectare)
SP71-1406	5.4	30	14.1
SP71-6163	1.1	15	13.7
SP70-1143	25.8	25	10.6
NA56-79	46.1	10	9.9
Other	21.6	20	10.8
Total	**100.0**	**100.0**	-

Source: COPERSUCAR, PROALCOOL, *Fundamentos e Perspectivas*, Copersucar (São Paulo, 1989).

Note: Figures are average results from a survey carried out in 27 mills located in the State of São Paulo.

Table II.3. Potential for reducing costs of ethanol production

Item	Potential cost reductions (percentage)
Sugar-cane production (agriculture)	
Variety selection and handling	9.8
Lime application	1.6
Liquid fertilizers	0.7
Sludge use	1.0
Weed removal	2.1
Transport	0.5
Operation planning	3.4
Ethanol production (industry)	
Milling	1.3
Fermentation	3.3
Distillation	0.3
Energy	1.5
Total	**23.1[a]**

Source: J. Goldemberg and others, The Brazilian Fuel-Alcohol Program in Renewable Energy-Sources for Fuels and Electricity, Johansson and others, eds. (Washington, D.C., *Island Press,* 1993).

[a]The total does not correspond to the sum of all items because some items are interrelated.

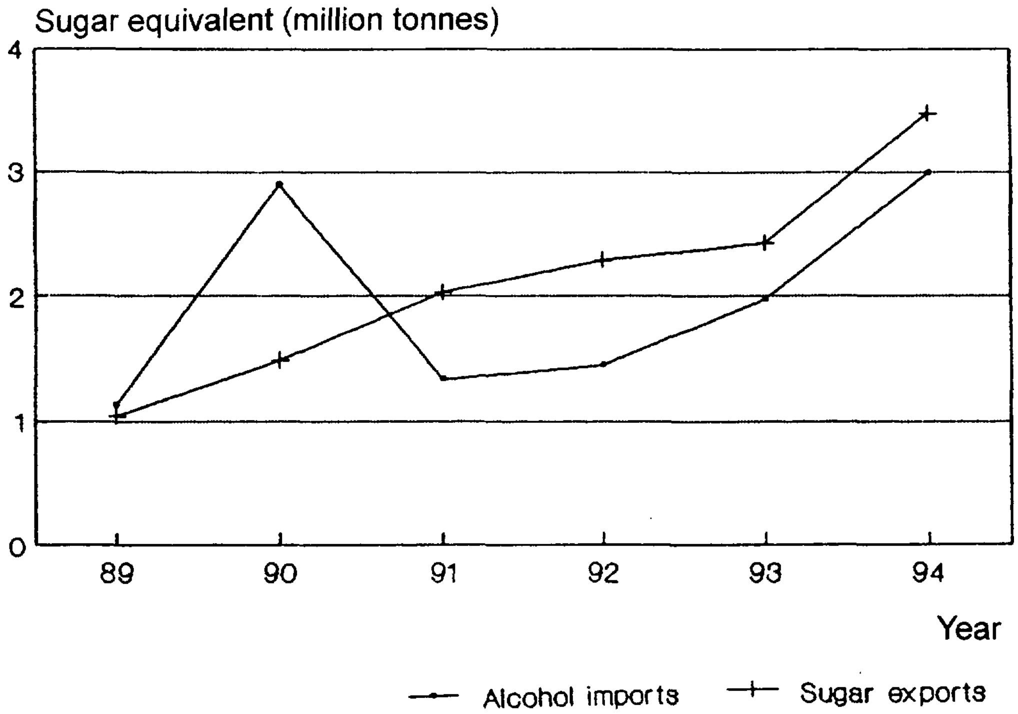
A new blend, composed of methanol (33 per cent), ethanol (60 per cent) and gasoline (7 per cent), known as MEG, was thus prepared, tested and marketed in 1990 [19, 20]. It is now commercially available in the State of São Paulo. The product allows perfect engine performance, and is compatible with metals, plastics and rubber parts, as well as with special coatings used on some automobile parts. MEG produces the same emission levels as ethanol fuel, and is safe to handle. In particular, the potential human health risk associated with the use of methanol was the subject of a complete environmental impact study [21], and in five years (mid-1990 to mid-1995), 2.78 billion litres of methanol was used without any reported health-related incident [22].

The option to use methanol as a fuel has allowed Brazil to export sugar during the last six years, when prices have been good and the production of sugar cane has been stable. Another factor has been the importation of ethanol to supplement internal supplies [23]. Figure II.5 shows the amount of sugar that was exported as a result of the importation of methanol and ethanol.

3. *Ethanol as a fuel for diesel engines*

Between 1980 and 1985, significant efforts were made in Brazil [24] and elsewhere to adjust the properties of ethanol to meet the minimum requirements of a diesel engine. Efforts concentrated on the addition of glow plugs and the use of appropriate blends and additives. After almost five years of laboratory and road tests, the only reasonable alternative identified was to add 5 to 6 per cent (on a weight basis) of diethylene glycol, an explosive, to ethanol [25]. Such high amounts made the blend too expensive for commercial use.

Figure II.5. Brazilian ethanol and methanol imports and sugar exports



Source: *DATAGRO*, No. 4 (1995), p. 11.

Another attempt involved the use of ethanol-fuelled Otto-type engines in trucks. As many as 3,000 such trucks were sold. The fuel performance, however, was too low compared with the diesel powered trucks [26].

C. Environmental issues

1. Soil quality

Sugar cane is a monocultural crop, grown year after year on the same land, and for this reason its yield might be expected to diminish over time. Yet the reverse is true. After decades of harvesting, Brazilian sugar-cane yield has been steadily increasing. Much of the increased productivity can be attributed to better soil preparation, development of superior cane varieties and the recycling of nutrients. Such techniques have greatly reduced erosion. Consequently, less topsoil is lost from sugar-cane fields than from the fields of most other monoculture crops in the State of São Paulo (12.4 tonnes per hectare per year, compared with 38.1 for beans, 26.7 for peanuts, 25.1 for rice, 20.1 for soybeans, 12 for corn and 33.9 for cassava [27]).

2. Water contamination

Today, cane washing water passes either through a closed circuit (in 90 per cent of the mills surveyed [28]) or through aeration lagoons; it is no longer dumped directly on the ground. Sludge from the lagoons is plowed back into the fields as fertilizer. Research on groundwater contamination shows that using such sludge as fertilizer does not cause water contamination if its use is limited to less than 400 m^3 per hectare per year [29].

3. *Air pollution at the production site*

Despite widespread concern, sugar cane is burned in almost all countries where it is produced. Pre-harvest burning (burning dry leaves) is intended to promote pest control and lower harvesting costs. Post-harvest burning (tops and remaining green leaves) eliminates trashy residue.

In Brazil, air-pollution concerns are exacerbated by the number of plantations near urban areas. Although investigations carried out in Hawaii show no health problems [30], such studies must continue. Cane-burning produces large amounts of smoke, and is thus viewed as a nuisance.

4. *Air pollution at the place of use*

The introduction of alcohol and gasohol has had an immediate impact on air quality in Brazil, eliminating tetraethyl lead in gasoline and reducing airborne lead levels. Other pollutants such as carbon monoxide and hydrogen chloride, as shown in table II.4, also declined, but nitrogen oxide and aldehyde emissions increased. Only after 1992, when electronic fuel-injection systems and catalytic converters were introduced in the market, were emissions substantially reduced. In 1994, these technologies were also applied to ethanol-fuelled cars with good results (see section A above). As yet, however, the relation between ethanol engines and the formation of ground-level ozone is not well understood [31].

Table II.4. Light vehicle emission in Brazil

Fuel	Pollutant, grams per kilometre			
	Carbon monoxide	Hydrocarbons	Nitrogen oxides	Aldehyde
Gasoline, before 1980	54	4.7	1.2	0.05
Gasoline, in 1986 (gasohol)[a]	22	2.0	1.9	0.02
Ethanol, in 1986[a]	16	1.6	1.8	0.06
Gasoline, after 1992[a]	4.90	0.44	0.62	0.015
Ethanol, 1995[b]	1.17	0.29	2.66	0.045

[a]Data provided by CETESB, São Paulo.

[b]Data provided by General Motors of Brazil, 1995.

5. *Global warming*

Ethanol produced from sugar cane may be a potent element in slowing global warming brought on by the build-up of carbon dioxide in the atmosphere. The major reasons are as follows:

(a) The production process uses only a small amount of external fossil fuel energy to meet the requirements of the agro-industrial energy system. Bagasse provides 100 per cent of the thermal energy and 92 per cent of the electricity needed to process sugar cane and produce ethanol [4];

(b) The carbon dioxide that is released during various stages (from the pre-burning and post-burning of sugar cane to the fermentation of cane juice, the burning of bagasse and, finally, the actual combustion of ethanol) is entirely recycled. Because sugar-cane growth is a renewable process, the carbon dioxide released to the atmosphere during the above cycle is fixed by the photosynthetic activity of the new crops.

If all the input energy used, including buildings and machinery, was derived from fossil fuel, then the ratio of energy in ethanol to energy in input (fossil fuel) would be 5.9 (or 8.2 in the best cases) [4]. Hence, the production and use of 1 litre of ethanol to replace gasoline avoids the emission of 0.54 to 0.57 kg of carbon as carbon dioxide, a 90 per cent reduction compared with gasoline [4].

D. Social issues

1. Employment and job quality

The impact of ethanol production on employment has been extensively analysed. So far, ethanol production has generated approximately 700,000 jobs with a relatively low index of seasonal work [32, 33]. The cost of creating a single job in the ethanol agro-industry varies from $12,000 to $22,000 [34], which is much below the average cost of creating a job; job costs for petrochemical projects can be as high as $500,000 [35].

Job quality is quite good when compared to other activities in the agricultural and industrial sectors. In the State of São Paulo, wages in the ethanol agro-industry are 80 per cent above the average in the agricultural sector [35], and 40 per cent above the average in industry.

2. Land use

Sugar cane used for ethanol production requires 4.1 per cent of the land area devoted to primary food crops (55 million hectares), and is behind corn, soybeans, beans and rice in space requirements [36]. That represents only 0.6 per cent of the area registered for economic use.

The results are also good when compared with the figures for the State of São Paulo, which accounts for two thirds of the sugar-cane production of the country. São Paulo has 15 million hectares of cultivable land, and only a half is used for agricultural purposes [32].

3. Hard-currency economy

The use of significant amounts of ethanol as an alternative to gasoline has an impact on the amount of oil imported. Brazil is a net importer of oil, and since 1976, through the use of ethanol and methanol-ethanol-gasoline (MEG), 119 million m^3 of gasoline, with a total value of $27 billion* in 1994 dollars have been replaced [37]. This figure must be compared with total investments for the ethanol programme ($11.3 billion) and current hard currency reserves of $45 billion in 1995 dollars [23].

E. Future prospects

Ethanol-powered automobiles sales have been declining for the last five years, and since 1994, the total fleet of such cars has been shrinking [38]. In 1994, the total subsidy provided by the Government reached $1.3 billion, most of which was used to pay state taxes [39]. Ethanol prices at the farms are set by the Government at $0.33 per litre, and at the pump stations at $0.45 per litre. Included in the final price are state taxes ($0.11 per litre), city taxes ($0.02 per litre), transportation costs and profit for

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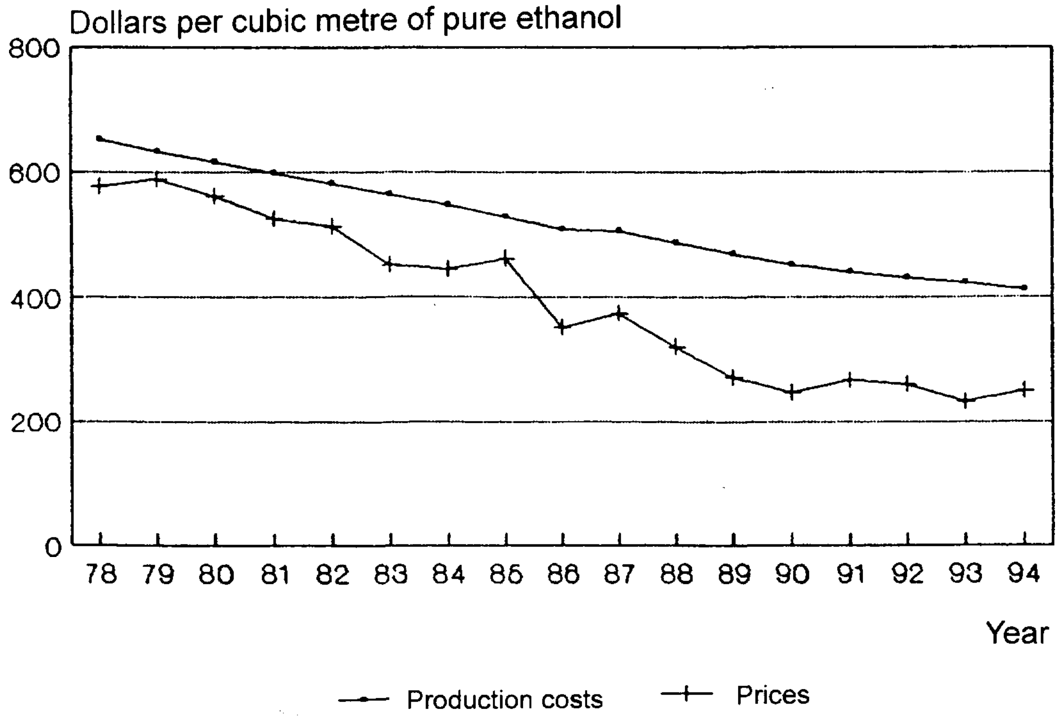
*The figure is even bigger, since Brazil has an external debt, and the importation of the displaced gasoline would have added more debt and interest charges paid by the country.

distributors and pump-station owners. State and city taxes alone add $0.13 per litre over the producer prices, making it unprofitable to sell the product at $0.45 per litre. Spreading the value of the total subsidy over 13 billion litres translates to $0.10 per litre, which is less than the taxes collected on the product. The government subsidy can be perceived as a carbon tax, which has been paid by Brazilians since the establishment of the alcohol programme in 1975.

Even the $0.33 received by producers is, on the average, below the actual production cost (see figure II.6). As a result, producers are less interested in ethanol, and are devoting more attention to the sugar market, which provides better revenue.* Efforts to achieve technology improvements have been reduced, and the Government currently has no strategic plan for the ethanol industry.

Figure II.6. Production costs and prices paid to ethanol producers (in 1994 dollars)



Source: *DATAGRO*, 1994.

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*During the 1994/95 harvesting season, 241 million tonnes of sugar cane were produced, showing an increase after several years of stable production of around 230 million. From that amount, 11,7 million tonnes of sugar and 12.7 million cubic metres of ethanol were produced, compared with 9.3 million tonnes of sugar and 11.3 million cubic metres of ethanol from the previous harvest (1993/94). Sugar exports reached 4.3 million tonnes, much above the 2.4 million tonnes of the previous season. Sugar prices were good, rising to $350 per tonne, and reducing the losses caused by low prices of ethanol. The increase in sugar production was made possible, in part, by imports of ethanol at an average price of $350 per tonne. Since production of 1 cubic metre of ethanol requires the same amount of sugar cane used to produce 1.67 tonnes of sugar, such imports of ethanol allowed exports of sugar at the rate of $584 per tonne [40].

Assuming the high drivability of the multipoint, electronic fuel-injection ethanol engines referred to in section A above, there is a possibility that car manufacturers, pushed by market pressure, will increase the share of new ethanol cars.

A more viable option, however, would be to find an international market for the product. Given the need for carbon dioxide abatement in response to concerns about global warming, it is reasonable to assume that ethanol can be marketed in developed countries as a gasoline blend with the potential to reduce carbon dioxide emissions and enhance octane levels. Once such a market is identified, new interest will develop and investments will become available to modernize ethanol processing plants, expand the programme and reduce costs.

Another positive stimulus to the market would be the definition of a better price for the acquisition of electricity produced in sugar-mills. With conventional technologies, the impact in favour of the producer would be modest. Ethanol provides a typical revenue of $25 per tonne of sugar cane, and the sale of electricity, at $0.05 per kilowatt-hour (kWh), could add $3.00 (with the generation of 73 kWh per tonne of cane and the use of 13 kWh in the process). The major impact would be in the value of the feedstock, which will become important as a source of energy for transportation and electricity, bringing more confidence to new potential investors.

III. SUGAR-CANE BAGASSE

A. Historical background

In 1993, the total sugar-cane bagasse production was 61 million tonnes, of which 1.9 million tonnes were used for electricity production and 59 million for heat production, 32.2 million tonnes of the total being consumed in ethanol mills, 26.7 million tonnes in the food and beverages industry and the rest in other industries [9]. Most of the bagasse consumed in the food and beverages industry was used to produce sugar (90 per cent) and orange juice (5 per cent) [41]. In Latin America, sugar-cane residues are the major source of biomass residues (3.58 exajoules per year), exceeding industrial roundwood residues (1.47 exajoules per year) and wood fuel/charcoal residues (2.12 exajoules per year) [42].

Such a huge amount of energy (12.3 x 10^6 toe) is now used inefficiently because most of the steam is produced in low-pressure boilers (2 megapascals). The processing of ethanol and sugar requires a small amount of electricity (approximately 14 kWh per tonne of sugar cane processed) and large amounts of low-pressure steam (450-500 kg per tonne of sugar cane processed at 0.3 megapascals) for distillation purposes. This energy could be consumed much more effectively, if a co-generation system was used for the efficient production of the required electricity and steam.*

In 1989, 60 industries were assessed for co-generation, limiting steam production to process needs, at an estimated cost of $0.05/kWh [43]. A more detailed study [44] evaluated the use of bagasse in condensing-extraction steam turbines and off-season electricity production using recovered cane tops and leaves [43].**

A number of biomass energy co-generation efforts are under way. With funds from GEF, a consortium of private and publicly owned companies is developing the Wood Brazilian Project (WBP) [45, 46], which is mainly designed to use wood and wood residues in a gasifier coupled with a 30-megawatt (MW) gas-turbine electric generator unit. The project has been under development since 1991. Phase I is completed, and Phase II, which should have been completed in June 1995, was scheduled for completion in June 1996. Phase I was a pre-feasibility study. Phase II, with an investment of $7.5 million, includes several tests on gasifiers (pressurized and non-pressurized) and gas-turbine modifications to define the best technologies and appropriate gas composition. The expected results from phase II are poorly defined [45], but a detailed report was to be published after completion of this phase. Phase III entails the construction of the 30 MW facility, and has already secured a grant of $23 million from GEF. Private investors are to finance the remainder, to fully cover the expected cost (approximately $65 million). The project received complementary financial support from GEF to make several trial runs using sugar-cane bagasse [48].

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*As much as 100 kWh per tonne of sugar cane processed at the mill can be generated using a condensing-extraction steam turbine [47].

**As much as 280 kWh per tonne of sugar cane can be generated using sugar-cane residues, if preharvest burn is avoided (green cane harvesting). For such crops, as much as 77 tonnes per hectare of above-ground dry matter has been obtained [42]. Using a biomass gasifier and gas turbine, 608-677 kWh per tonne of cane can be produced [47], leaving in the field 32 per cent of tops and leaves for environmental reasons.

Another effort involved an agreement between the State of São Paulo Public Utilities and sugar-mills to generate surplus electricity up to a capacity of 300 MW for sale through the utility grid at marginal cost. Several mills (11) in the State of São Paulo had been selling electricity to the grid, but immediately after the agreement, the marginal electricity cost decreased, from $41 to $32 per megawatt-hour (MWh), which is too low to attract new parties.* Interested entrepreneurs from abroad were planning to invest in co-generation projects, but are deferred by the low electricity prices.**

B. Environmental aspects

Probably the biggest environmental issue is concerned with the preharvest and post-harvest burning of sugar-cane residues and with the inefficient use of sugar-cane bagasse as a source of energy. As already discussed, carbon dioxide emissions from ethanol production and use is very low as compared with gasoline, but further carbon dioxide abatement could be obtained if:

(a) Sugar-cane bagasse is used for the production of electricity in all sugar-mills;

(b) Sugar-cane bagasse is used for co-generation in high-efficiency systems;

(c) Sugar-cane residues derived from harvesting unburned cane (known as "green cane" harvesting) are used as fuel.

Green cane harvesting is highly desirable from a local and global point of view. At the local level, it eliminates the air pollution problem associated with cane burning, and allows the production of energy with little use of fossil fuel. Globally it is possible to convert the 911 million tonnes of cane available from the sugar-cane industry in all developing countries to 605 TWh per year, using modern technologies [47]. In Brazil alone, there is potential for generation of 160 TWh per year, which is 67 per cent of the total annual electricity consumption (240 TWh per year)

C. Social issues

Job creation in rural areas is the major positive aspect of the use of sugar-cane bagasse as a fuel. Green cane harvesting implies the harvesting of almost twice the weight of sugar cane currently harvested and the transport of 60 per cent more material from the field to the sugar-mills. That would require, however, more profitable utilization of the planted biomass, as well as mechanization of green cane harvesting. Manual harvesting is not recommended, since sharp leaves make human work difficult, and the presence of animals (like snakes) is a risk for workers. Consequently, harvest productivity (tonnes of cane per worker) decreases, with an adverse impact on the cost of final products. Currently, 9 per cent of the sugar cane in Brazil is harvested by machine, and the equipment required is highly sophisticated [50]. The current use of machinery is motivated not by economics, but by the shortage of manpower in some rural regions.

D. Future prospects

Bagasse consumption in the sugar and ethanol mills can be significantly reduced, mainly through a reduction in steam requirements [51]. The total bagasse produced has an energy content of 12.5 million

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*Such figures are the subject of continuous debate. The public sector investment in electricity supply has been very high (an average of $6,200 per kW effectively demanded over the last 23 years); even so, marginal cost evaluations recently carried out quote value for generation as low as $0.032 per kWh.

**TransAlta utility of Alberta, Canada, is seeking to enter a partnership in a co-generation plant using sugar-cane bagasse as fuel in Brazil [49].

toe. This amount of energy can potentially be doubled if green cane is also harvested and utilized. Much more electricity could then be produced, as discussed in section A above. The generation of 600 kWh per tonne of cane could provide a revenue of $30 per tonne of cane, making electricity the main source of revenue for the industry. Cost-benefit analysis for the above scenario has already been done, and it is possible that, with the introduction of new technologies, this option could attract investors [45].

Sugar-cane bagasse is already being used for other purposes, such as cattle-feeding (approximately 200,000 tonnes were used to complement fodder during the dry year of 1994 [48]) and agroindustrial uses for steam production. All those uses, however, represent a small market for the huge volume of bagasse potentially available, if modern, efficient technologies are used in the sugar-mills.

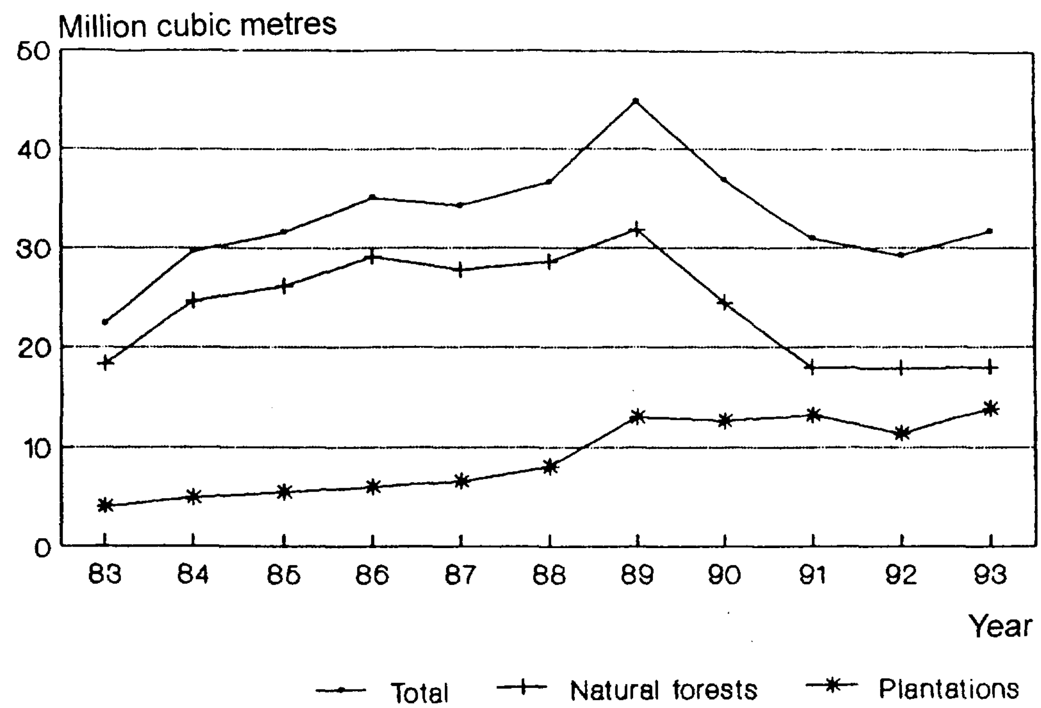
IV. CHARCOAL

A. Market evolution

Use of charcoal is widespread in Brazil, as in many other developing countries. Sustaining its continuous production and use, mainly for industrial purposes, is, however, a major cause of concern, since it involves the uprooting of wooded areas, the destruction of vegetation and land erosion. For some industrial uses, charcoal is the preferred choice, because of its high energy density (about 30 gigajoules per tonne), compared with firewood, and its relative ease of transport, compared with wood.

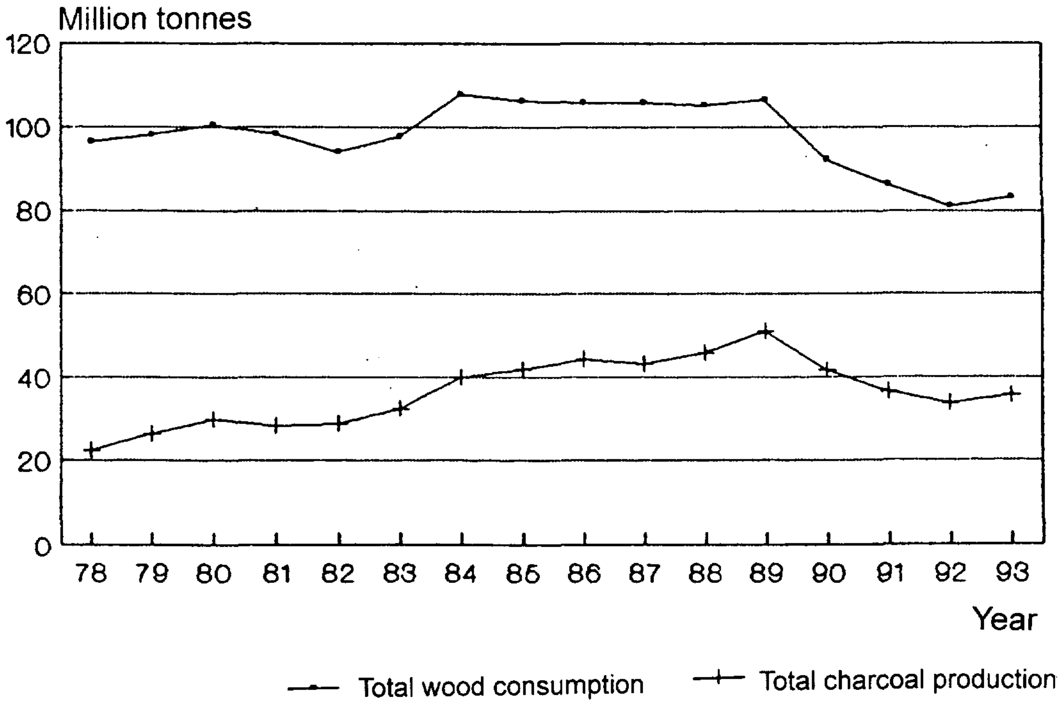
During the 1980s, as a result of increased efficiency in the production of charcoal from wood and the switch from forest wood sources to plantation-derived wood, Brazil was able to increase its charcoal utilization significantly, without increasing charcoal production from forest sources [3]. Charcoal consumption peaked in 1989, when 50.9 million tonnes of wood resources were used for its production, then declined continuously through 1993, when 35.6 million tonnes of wood resources were used (see figures IV.1 and IV.2). In a five-year period (1989-1993), from 43 to 48 per cent of the total wood consumed in Brazil was used for charcoal production (Figure IV.2) [9].

Figure IV.1. Charcoal consumption according to wood source



Source: *ABRACAVE*, 1993/94.

Figure IV.2. Wood consumption for charcoal production in Brazil



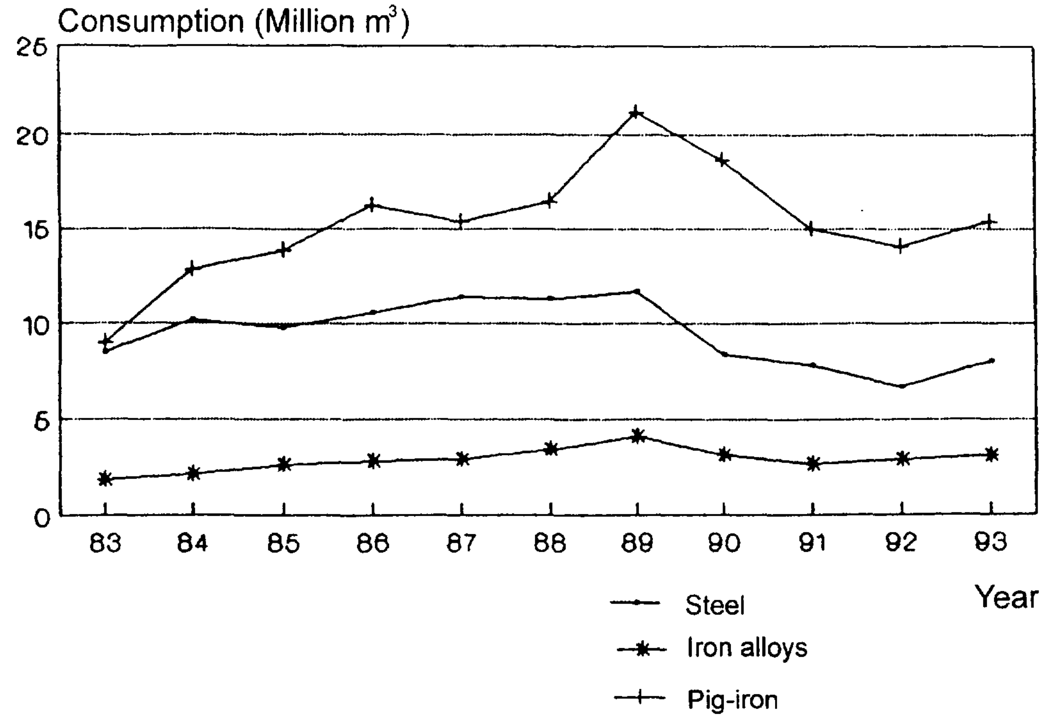
Source: BEN/1994 and MME/Brazil.

Large amounts of charcoal are consumed in the reduction and heating of iron or for pig-iron and steel production (see figure IV.3). Of the 11.6 million tonnes consumed in the peak production year of 1989, 10.4 million tonnes were for industrial uses, the pig-iron and steel industry accounting for 8.2 million tonnes and the iron alloys industry for 1.0 million tonnes. Since then, total charcoal consumption has declined to nearly 8.0 million tonnes, with a faster decline in the industrial sector (about 7.0 million tonnes) [9]. Such a decline is due to the increase in charcoal prices as a result of the enforcement of a law requiring a growing participation of planted forest in charcoal production. A federal regulation (decree number 97.628 of 1989) required that the percentage of charcoal derived from plantation wood should reach 100 per cent by 1995 in accordance with the following scheme: 1989, 40 per cent; 1990, 50 per cent; and 1995, 100 per cent.

The same decree, however, allows the production of 20 per cent of charcoal from forest residue. Therefore, in reality, the maximum amount of charcoal derived from plantation wood between 1989 and 1993 would be 80 per cent [3]. According to *ABRACAVE*, charcoal from planted forests accounted for less than 40 per cent of the total supply (see figure IV.1).

Costs of wood production for charcoal are highly dependent on the original cost of the land, soil type, yield and relief. The average production cost in 1992 was over \$5 per m^3 of charcoal (about \$3.5 per gigajoule), and the average transport cost was \$0.0125 per m^3 per kilometre, yielding delivered charcoal prices in the range of \$3.8 to \$4.4 per gigajoule [52].

Figure IV.3. Consumption of charcoal in the Brazilian iron industry



Source: *ABRACAVE*, 1993/94 and IBS, 1993.

Note: 1 m^3 = 0.25 tonne = 0.16 tonnes of oil equivalent.

B. Technology

Charcoal is produced through wood pyrolysis, a very old technology. Traditional methods of charcoal production have centred on the use of earth mounds or covered pits into which the wood is piled. Control of the reaction condition is often crude and relies heavily on experience. The conversion efficiency using these traditional techniques is very low; on a weight basis, Openshaw estimates that the wood-to-charcoal conversion ratio ranges from 6 to 12 tonnes of wood per tonne of charcoal [53]. Modernization of the charcoal production industry was stimulated by regulations on the use of planted forest (decree number 97,628), since the large iron- and steel-producing companies have been forced to obtain reliable supplies of plantation charcoal. This has led to many of them to invest in the development of large plantation and charcoal production facilities. Such competition has resulted in a need for increased yields, efficiency and benefits from economies of scale.

Larger kiln sizes can allow partial mechanization of the materials-handling process, allowing shorter production cycles (as short as seven days). The carbonization process is also more closely controlled, increasing conversion efficiency. Some of the larger kilns allow tar and oil recuperation, providing financial gain and reducing environmental damage from the leakage of oil into surrounding soil. Nevertheless, the ovens are made of bricks and mud and are internally heated, which means that a fraction of the wood (20 per cent by weight) is burned and sacrificed. Significant potential thus exists for efficiency improvements, for example, using externally heated and hot circulating gas. To realize this potential, however, substantial investment is required [54].

Another way of improving efficiency is to collect and use the liquid fraction of the exhausts from charcoal ovens. Through condensation and processing of the exhausts, it is possible to recover 0.24 toe per tonne of charcoal produced as vegetable tar, a dark brown oil with a density of 1.15 grams per cubic centimetre [55]. The vegetable tar can be further processed (starting with water removal) yielding 600 kg of by-products per tonne of vegetable tar (see table IV.1). The tar can also be burned, as it is now, in industrial ovens and boilers, replacing other fuels. Unfortunately, the use of vegetable tar as a fuel is not an attractive option, because of low fossil prices. As yet, efforts to identify potential markets for the by-products have not been successful [55]. The investments required for vegetable tar collection are high compared with those for conventional charcoal production. An investment analysis, performed by Florestal Acesita S.A. [56], concluded that for a large rational charcoal and by-products facility (2.6 x 10^6 m^3 per year), it is necessary to invest six times more in the tar recovery equipment than in the brick beehive kilns. The study assumes a production cost for charcoal of $63.88 per tonne (in 1983 dollars), if charcoal is the only saleable product, and a total charcoal oven investment of $1.52 x 10^6 for an annual production of 2.56 x 10^6 m^3 per year, or less than $1 per m^3 per year. With regard to tar, total annual production is expected to be 90,000 tonnes per year with an investment of $9.53 x 10^6, or $106 per tonne per year. Considering the real capital cost in Brazil (30 per cent per year), this means that capital investment contributes $0.30 per m^3 for charcoal, which is less than 0.5 per cent of the production cost ($63.88), but contributes $32 per tonne of tar. Also, the energy content of tar is only 60 per cent of oil-derived fuel, which means that the actual investment cost is $32/0.6, or $53, per tonne. The price of fuel oil is as low as $100 per tonne plus transport costs. Thus, vegetable tar production must be below $47 (100-53) per tonne, which is very difficult to achieve.

With regard to production and sale of the several by-products which can be obtained from vegetable tar processing, the potential revenue is high (see table IV.1), but market identification is difficult, and investment can be very risky. Some commercial experience has been recorded. Biocarbo, a small company, is trying to process tar collected by Belgo Mineira, and sells some of the fractions obtained in a pilot facility to the external market. The fractions are used for veterinary, pharmaceutical and food applications, and have a high market value [57].

The possibility of simultaneous charcoal and electricity production is presented in Plan 2015 [58].* It notes that charcoal is made in continuous carbonization ovens loaded with infield, predried wood transported to the facility. Exhaust gases with tars and solid particulate are burned in a boiler along with wood and charcoal fines. Steam produced by the boiler is directed to a steam turbine coupled with an electric generator [58]. Economic analysis shows that the cost of electricity varies between $37 and $147 per MWh, depending on the investment costs of the electric and charcoal units, as well as the cost of wood and the market price of charcoal.

Another technical advancement involves injection of charcoal fines, which have no commercial value, in blast-furnaces, when conventional ore reduction process occurs. The fines can be injected through the air ventilation ports of blast-furnaces. The charcoal charge is 75 per cent granular (normal charge) and 25 per cent fines. This combination increases pig-iron production by 10 per cent. The technique is being used in a growing way in Brazil, and if the technology is adopted by the entire pig-iron industry, it could potentially save 1.9 x 10^6 tonnes per year of charcoal and 11,000 tonnes of diesel oil needed to transport the charcoal [59]. The most important consequence of this scenario, should it take place, would be the preservation of 1,000 hectares per day of forest, which would not have to be harvested.

*Plan 2015 is the official plan of the Brazilian electric sector, and is designed to forecast all new electricity generation and transmission activities up to the year 2015.

Table IV.1. Major by-products obtained from condensation of air exhausts from brick beehive kilns

Product	Production (kg/tonnes of charcoal)	Price ($ per kg)	Revenue ($ per tonne of charcoal)
Acetic acid	150	0.40	60
Phenol	3.2	0.70	2
Cyclodiene	3.0	90.00	270
o-cresol	3.0	2.50	7
m- and p-cresol	4.6	2.50	11
Menthol	0.9	100.00	90
2-4[a] dimethyl and phenol	2.3	4.60	3
Guaiacol	6.6	10.00	66
Creosol	7.5	4.40	36
Ethyl guaiacol	5.8	10.00	58
Syringol (2-6...)	18.1	10.00	181
Methyl syringol	14.7	10.00	147
Ethyl syringol	8.7	10.00	87
Others	40	0.40	16
Solid tar	200	0.20	40
Total potential revenue per tonne of charcoal	-	-	**1,174**

Source: Cia de Aços Especiais Itabira, "Modernização de produção do carvão vegetal" (Belo Horizonte, Brazil, 1991).

C. Environmental aspects

From the global point of view, charcoal use has a positive impact. It can be obtained from a primary renewable source of energy, and be produced and used in a self-sustaining way through planted or managed forests. Analytical results available for the complete production cycle of pig-iron and steel in Brazil show advantages in greenhouse-gas emissions from the use of charcoal as compared with coke [60]. Table IV.2 shows that 1 tonne of pig-iron produced using charcoal removes 362 kg of carbon dioxide from the atmosphere, while production of the same amount with coke adds 1,883 kg of carbon dioxide. Also, the total oxygen demand of coke is much higher (1,274 kg) than that of charcoal (236 kg) when complete energy and chemical cycles are considered, starting with photosynthesis and finishing with the blast-furnace operation. The results could be even better for charcoal if the condensates (all condensates and gases are oxidized) were collected and considered as final products, in which case a reduction of 1.2 tonnes of carbon dioxide per tonne of pig-iron could be achieved.

At the local level, air pollution caused by particulates and condensates can cause health problems for workers involved in charcoal production. The problem could be worse for small producers who employ their families in the operation, and usually unload the ovens before complete combustion has occurred in order to save time. Another problem is that such pollution can interfere with the process of pollination of Brazil-nut trees [61].

Table IV.2. Carbon dioxide and oxygen material balance in the pig-iron industry

	Carbon dioxide production		Oxygen consumption	
Process	Charcoal (kg per tonne of pig-iron)	Coke (kg per tonne of pig-iron)	Charcoal (kg per tonne of pig-iron)	Coke (kg per tonne of pig-iron)
Charcoal/coke production	1,496[a, b, c]	160[d, e]	985	306
Sinter preparation[f]	170[g]	134[h]	269	284
Reduction[f]	1,791[i]	1,589[j]	829	684
Sub-total	3,457	1,883	2,083	1,274
Photosynthesis	(3,819)	-	(1,847)	-
Total	**(362)**	**1,883**	**236**	**1,274**

Source: M.C.F. Melo and others, "Siderurgia auto-sustentada e a questão ambiental" (Belo Horizonte, Brazil, Cia Aços Especiais Itabira, 1992).

Note: Figures in parentheses are negative.

[a]Commercial forest productivity was assumed as 12.57 per hectare per year, which means a total of 21.5 tonnes per hectare of biomass (including 1.13 tonnes of roots, 1.88 tonnes of small trunks, 1.75 tonnes of leaves and 4.25 tonnes of products that fall to the soil during one year; leaves, small trunks and products are not included in the chemical balance since they decompose on the soil, returning carbon dioxide to the air).

[b]One tonne of commercial wood is converted to 333 kg of charcoal, 197 kg of condensates and 261 kg of gases, with the emission of 1,496 kg of carbon dioxide per tonne of pig-iron.

[c]All condensates and gases are oxidized.

[d]One t of coal is transformed to 0.75 tonne of coke, 113 kg of condensates and 137 kg of gases, with carbon dioxide emissions of 160 kg per tonne of pig-iron.

[e]Since condensates are already collected in steel mills using coke, they are considered as final products. Only gases are oxidized.

[f]All carbon monoxide production is considered to be fully oxidized to carbon dioxide.

[g]For the sinter preparation, 695 kg of charcoal is used per tonne of pig-iron, yielding 1,034 kg of carbon dioxide and 261 kg of carbon monoxide.

[h]For the sinter preparation, 603 kg of coke is used per tonne of pig-iron, yielding 985 kg of carbon dioxide and 98 kg of carbon monoxide.

[i]Blast-furnace operation requires 636 kg of charcoal per tonne of pig-iron, and yields 750 kg of carbon dioxide and 624 kg of carbon monoxide.

[j]Blast-furnace operation requires 519 kg of coke per tonne of pig-iron, and yields 738 kg of carbon dioxide and 519 kg of carbon monoxide.

D. Social issues

Production of charcoal has a large impact on the creation of jobs in rural areas. According to ABRACAVE, the 10 million tonnes of charcoal produced in 1989 (used for making 35 per cent of the pig-iron and 98 per cent of the iron alloy output of the country), generated a revenue of $5 billion and created 270,000 jobs [62].

Forest plantations, which supply at least half the biomass used for charcoal production, has relied heavily on eucalyptus, since it grows quickly (in six or seven years) and has a high yield. Consequently, some rural villagers have already been described as "prisoners of the eucalyptus" [63]. Hemmed in on all sides by commercial reforestation areas, the villagers have trouble finding land to grow their food on.

Such conflicts have been induced by the exploitation of native forests. Most recently, in the new pig-iron centre in the State of Pará, in Amazonia, the Indians and the old immigrant population (which arrived during the 1960s) have been in conflict with new foreigners, attracted to the mineral centre of the Grande Carajás Project. To meet local demand, 2,500 families are involved in the production of charcoal, since the well-organized industries are only able to supply 22 per cent of the total demand [61]. As native forests near the industrial centre are exhausted, other land is invaded, creating conflicts. Such problems must be urgently dealt with; planting forests, for example, could create enough employment opportunities.

E. Future prospects

It is very difficult to make a reasonable forecast. While regulations against deforestation are limiting the use of low-cost sources of wood fuel for charcoal production, no reward is being offered for the efforts to produce charcoal from planted forests. The lack of tax incentives and of efforts to open up the economy of the country has resulted in charcoal prices that are higher than the price of imported metallurgical coal.

Even the better quality of the final product is not enough to offset the fuel cost differences. In the same way, member countries of the Organisation for Economic Co-operation and Development (OECD) are considering creating obstacles for wood products made from native wood and exported to them. It is essential to find mechanisms* to promote steel and steel products made from sustainable and renewable sources. If help from developed countries does not come, utilization of charcoal can be expected to decline significantly.**

Because of the difficulty of carrying out a precise cost analysis, it is recommended that the proposed integrated charcoal-electricity production system should be commercially tested [58].

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*Carbon taxes, tradable permits, hidden costs and wood subsidies are some of those mechanisms [3].

**Some large integrated steel-mills have already decided to replace charcoal by coke. Belgo Mineira and Acesita were to start using coke in 1996 and should complete the change-over by the year 2000. Independent producers have no alternative, because of the lack of capital for investment, other than to continue to use charcoal [57].

V. VEGETABLE OILS

A. Overview

Vegetable oil is not now considered a source of energy in the energy mix of Brazil. Large amounts of vegetable oil are produced mainly from soy bean and other crops, and used for food and by the chemical industry. As a result, however, of the growing international interest in replacement of diesel oil by renewable alternatives, efforts have been made to demonstrate the feasibility of using vegetable oils, as fuel for modified diesel motors or for multifuel diesel engines. The main motivation is that more than 40,000 villages (with up to 100 households each) lack electricity, and will not be connected to the existing electric grid for a long time, because of the high cost of extending the grid through sparsely populated areas. Installation of motor-generator units using diesel oil is not appropriate, since the communities are very poor. Using diesel-based electricity requires money to be available for transfer from the community to the big cities for payment of the fuel. One possible approach is the use of native oil plants which can be harvested and collected by local workers, and processed for production of oil and by-products. The oil can be used to fuel motor-generator units or for pumping water. A major advantage is that even though money is necessary for the payment of the electricity bills, it will remain in the community yielding local benefits [64].

Such an approach obviously requires an initial investment and production and maintenance expenditures. The initial investment should be the responsibility of the Government, since the concept aims at improving the quality of life in the rural areas. Production and maintenance costs are expected to be paid, at least partially, from local revenues that should be generated as oil and by-products are commercialized. One utility in the State of Minas Gerais is currently testing this approach at three different sites, using pre-chamber diesel engines and multifuel engines manufactured in Germany [65].

Another interesting option is the generation of electricity in cities with populations of below 20,000 located in the Amazon region, where electricity is currently supplied by diesel engines of up to 3,000 horsepower. The electric tariff paid by consumers is uniform* throughout the country, and this requires a subsidy. A subsidy is provided by the majority of consumers living in the big cities, where hydroelectricity is available, and is transferred to a few of the small cities where thermoelectricity is used. When produced from diesel oil, the cost of thermoelectricity to consumers in the Amazon region is $160 per MWh, which is much higher than the average price of $60 per MWh, charged countrywide [66]. Because of the high cost of generation, the government is considering the possibility of using modified diesel engines fuelled with "in natura" vegetable oil. Again, the important consideration is the potential for local employment and the establishment of a commercial activity, without the need to transfer money elsewhere to purchase fuel. For this, the intention is to use a few specific native oil fruits found in large amounts (e.g. Brazil nut and buriti) or to establish oil crops.

The best candidate for such energy crops is palm oil. Palm trees grow very easily in most of the Amazon region because of the abundant rainfall. Palm trees in the Amazon are planted by companies that exploit them for commercial purposes. Palm oil has a growing international market acceptance and a high value (currently $500 per tonne, but an average historical international price of $400 per tonne).

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*Since 1993, the tariff can be different for each utility (law number 8631 of March 1993). Nevertheless, the price differences have thus far been very small, since price changes must be approved by the Federal Government.

Production cost, however, is nearly \$250 per tonne and, at that level, palm oil could compete with diesel oil if subsidies, mainly the one that cover transport costs, were removed (the price of diesel oil at all pump stations is \$400 per tonne, including taxes, distribution costs and profit).

The ever-present discussion about food and fuel competition is easy to handle. The proposal is to grow palm-oil crops near cities of less than 20,000 people, which require very little area,* as compared with the size of the Amazon region. Even if the existence of national and international demand for palm oil for food purposes is considered, the issue is not pertinent, since in these communities, transport costs make the product too expensive for export.

B. Technology

Except for traditional vegetable oils (corn, soy bean, peanut, cotton, sunflower and palm oil), there is no technical experience in the production of oil from other native oil plants (a few entrepreneurs are involved, using very crude approaches [64]). Even for traditional vegetable oil processing with emphasis on fuel, such as palm-oil processing, the technology can be further improved to reduce cost, as happened with fuel ethanol production in Brazil during the past 15 years.

Palm oil is processed using energy derived from biomass and from diesel oil at most of the production sites. Biomass is used as a fuel for steam generation, and diesel oil is used for electricity production. But in the most advanced units, co-generation is used, supplying electricity and steam from the fruit residues (fibres and nut shells) [68]. Hence no fossil fuel is used in the palm-oil production process (see section C below). Abundance of fibre and nut shells at the palm-oil processing facilities, together with high-efficiency steam turbines, allows overproduction of electricity which can be sold to the grid or other industries or villages in the surrounding area [67].

The large-scale production of palm oil can be an option to power not only stationary multifuel diesel engines, but also trucks and boats, mainly in the Amazon region. These multifuel engines can use vegetable oil and diesel, which means that regional availability of the fuel should not be a problem.

C. Environmental issues

1. Local effects

Production of vegetable oil from a native plantation is based on extraction, and as such should stimulate forest preservation, providing commercial value to the existent vegetation. Processing on a small scale, even using obsolete technologies, should not cause any serious air or water pollution problems.

Creation of job opportunities in the Amazon region is a very effective way of preserving forest and abating carbon dioxide emissions. Lack of employment opportunities in the rural areas force poor people to seek employment at cattle ranches, activities which are the major cause of deforestation. Extensive cattle-ranching is common in the region, because of the low labour cost. A worker can take care of 400 head of cattle, and owing to the low quality of the land, cattle density is one head per hectare. One worker employed in this activity can represent deforestation of 400 hectares, subsequent burning yielding

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*Palm-oil productivity is 4,000 litres per hectare per year. Per capita electricity consumption is 1,000 kWh per year, requiring 300 litres per year. A city with 20,000 inhabitants consumes 6,000,000 litres per year, which can be obtained from 1,500 hectares of plantation [67].

a carbon dioxide emission (including potential loss of carbon from the soil*) of as much as 40,000 tonnes of carbon.**

Production of vegetable oil by large industries, based on palm-oil crops, has several environmental advantages. Palm oil is a perennial crop (can be exploited for 20 years, beginning 5 years after plantation), and as such produces soil erosion at levels much below annual crops. Being an imported plant, it requires careful handling to prevent diseases. One common approach is to preserve part of the natural vegetation surrounding the palm-oil crops. Thus, biodiversity is preserved.

Another source of local pollution is the waste water, which has oil and organic residues, and thus a high chemical oxygen demand (COD). This water is currently treated by aerobic fermentation in artificial ponds before being returned to rivers. In large-scale production, the water can be treated in a biodigestor, yielding energy [67], and after that dumped on the soil, as is being done in most of the ethanol processing plants.

2. *Global effects*

At the global level, the use of palm oil as a fuel displaces diesel oil, abating carbon dioxide emissions. As already discussed, palm-oil production can use its own residues as a source of energy for the processing facility, and also as a source of fertilizer. Residues are returned to the soil, reducing the need for artificial fertilizer [67].

D. Social issues

The opportunity to create jobs in rural areas is important to avoid migration to the cities. Palm-oil production can give the local population access to money and enable it to perform a minimum of agricultural activities to provide their own food. The average number of jobs is 30 to 40 per 1,000 tonnes of palm oil produced yearly [67].

E. Future prospects

The prospects for vegetable oil are very good, at least during the demonstration phase. In Europe and in the United States, mainly biodiesel (defined as monoalkyl esters of long-chain fatty acids derived from renewable lipid sources [73]) is being tested with excellent technical results [74-77]. Vegetable oil is also being transformed into a diesel alternative by direct hydrotreating [78].

Prompted by the wide-spread international interest, Brazil is carrying out some experimental studies on the production and use of vegetable oil fuels. Most of the efforts are in the direction of using vegetable oil in multifuel engines, and a few are planned to use hydrotreating [64, 65]. The major obstacle in Brazil as elsewhere is the high cost of vegetable oil. Soy-bean oil and palm oil are priced in

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*Overall release of carbon dioxide from land-use conversion is thought to be in the range of 1.6 +/- 1.0 picograms of carbon per year [70]. Of the carbon losses attributed to land use, loss of carbon from the soil has been estimated to account for 20-40 per cent [97, 98]. Recent data, however, suggest that loss of carbon from the soil following deforestation may have been overestimated, particularly for forest conversion to pasture, where carbon levels in the soil can recover to levels equal to or higher than native forest within a few years [69, 71].

**The most significant carbon conservation clearly would occur in the tropics, where each MHA of deforestation produces about 0.1 picograms of carbon net flux . This is the flux obtained considering a carbon pool of 212 picograms at the vegetation level and 216 picograms at the soil level for low-latitude forest vegetation (above- and below-ground living and dead mass, including woody debris) and soil (oxygen and mineral levels to a depth of 1 m) and assuming 15.6 million hectares of annual deforestation [72].

the range of $450 to $500 per tonne [79]. Even "off-specification" green canola oil and palm oil may be priced at more than $300 per tonne [78]. Thus, the present economics of biodiesel fuel in OECD countries is heavily dependent on generous subsidies given to farmers for growing non-food oil-seed crops and substantial concessions on fuel excise taxes [80, 81]. In Brazil, neither of these subsidies is available, and the possibility that small-scale projects will motivate a larger programme is dubious. Clearly, if a large biodiesel programme is installed, national subsidies will not be available.

VI. FIREWOOD

A. Description of the problem

Total consumption of firewood reached a peak of 107 million tonnes in 1984, and stabilized around that figure until 1989. It then declined steadily to 81 million tonnes in 1992, showing a small increase in 1993 (83 million tonnes). Charcoal production represents approximately 40 per cent, residential uses 30 per cent (25 million tonnes), industrial activities 20 per cent, and agricultural activities the remaining 10 per cent of the total firewood consumption [9].

Residential use has been declining steadily, from 50 million tonnes in 1978 to 25 million tonnes from 1990 to 1993. Industrial use (mainly in the food and beverages industry, in the ceramic industry and in pulp and paper) declined from a peak of 21.6 million in 1986 to 15.7 million in 1993. Consumption dropped in all industries, with the smallest decline in pulp and paper. Agricultural use declined steadily from 11.6 million tonnes in 1978 to 6.0 million tonnes in 1993 [9].

As already discussed, residential and agricultural uses are not a significant concern, since they are scattered throughout the country, and the level of use is insignificant (2.3 and 1.2 gigajoules per capita per year, respectively), compared with the natural rate of growth of vegetation in the country, which is higher than 90 gigajoules per capita per year [11]. Nevertheless, there are particular areas, mainly in the dry north-east region, where shortage of firewood occurs [82]. In the north of the country, where most of the Amazon rainforest is located, firewood from the native forest is used, but in amounts that have a small impact on deforestation. Since Amazon deforestation and potential reforestation of the already degraded areas are important environmental issues, some of the major problems are discussed in the next session.

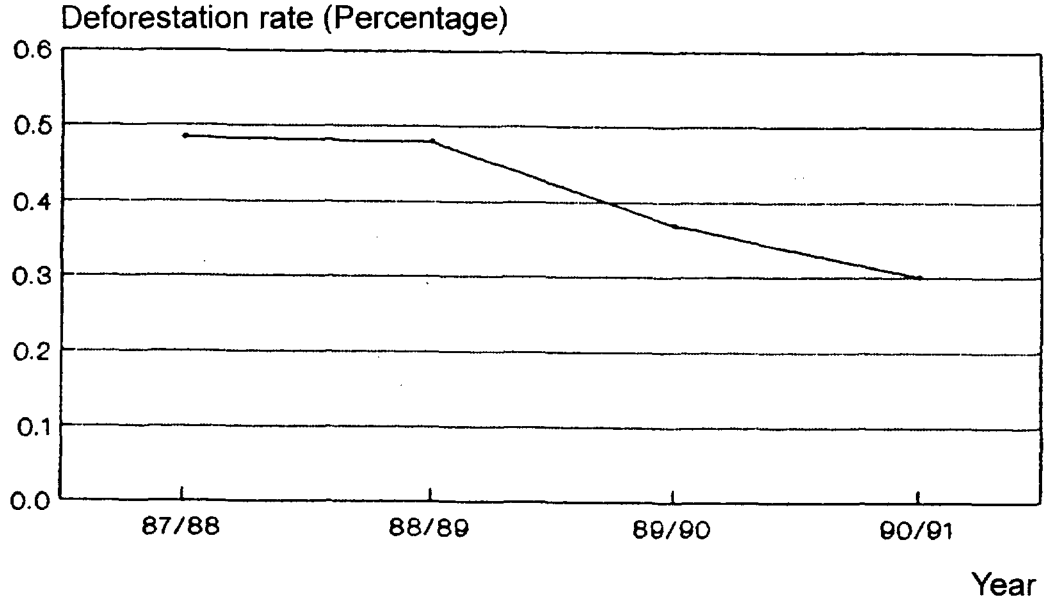
B. The Amazon forest

Most of the forests in Brazil are classified as low-latitude forests, a type experiencing high rates of loss, estimated at about 15.4 million hectares per year from 1980 to 1990. Much of the deforested area is converted to new agricultural land or pasture, often replacing degraded agricultural lands that may or may not be capable of supporting tree covers [83, 84].

In Brazil, as in a few other tropical countries, deforestation has decreased during the last decade, as shown in figure VI.1 [85]. In addition to a reduction in area, large parts of forests are harvested and degraded. According to the Food and Agriculture Organization of the United Nations (FAO) [86], 5.9 million hectares per year of low-latitude forests were logged from 1986 to 1990, and most logging (83 per cent) occurred in mature forests rather than secondary forests. Also, forest management covers less than 4 per cent of the low-latitude forests.

Most biomass burning in tropical forests is intentional and associated with land-clearing activities. Wildfires also occur, however, in tropical moist and dry forests, and can be caused by the drying of organic material at the surface of degraded lands, as well as by changes in the microclimate of forest remnants surrounded by deforested areas [87]. Since as much carbon occurs in forest soils as in vegetation,* radiation forcing is increased by carbon changes in the soil resulting from forest destruction or exploitation. Opportunities to manage forest soil and to sequester carbon are therefore significant. The tropics have the potential to conserve and sequester 80 per cent of the carbon potential of all world forests [88, 89].

Figure VI.1. Rate of legal deforestation in Brazilian Amazonia



Source: Pandolfo, 1994.

Note: The deforestation rate in 1990/91 was 11,130 square kilometres per year.

In Brazil, use of biomass (lumbering) is only one component in the list of causes of environmental destruction. Other causes are cattle-ranching, agribusiness, slash-and-burn agriculture, hydroelectric power and mining.

Cattle pastures dominate land use in deforested areas of the Brazilian Amazonia, greatly magnifying the impact of a small human population (less than one inhabitant per square kilometre) on the forest [90]. The yield of beef is minuscule (one head per hectare of pasture) because of the decline in available phosphorus in the soil, soil compaction, erosion and invasion by inedible weeds [91]). Maintaining pasture productivity past the first decade requires inputs of phosphates [92]. Given the poor agronomic performance and unpromising long-term prospects of pasture, the reasons for the domination of the landscape by such land use lie elsewhere.

One reason has been the generous set of financial incentives granted to large ranchers in Amazonia by the Government of Brazil. Special loans have been provided at interest rates below the rate of

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*FAO [7, 8] estimates that low-latitude forests in America store 199 picograms of carbon in the vegetation and 110 picograms of carbon in the soil.

Brazilian inflation. Government subsidies accounted for up to 75 per cent of the investment in the ranches [93].

Programmes for subsidizing ranches ceased to expand after 1979, when no new incentives were available for the high-forest area of the Amazon, but those applying to the other 300 projects under way were maintained [94]. Subsidized ranching is still an important factor in deforestation, but the economic crisis of the country reduced the amount of money available for that purpose during the 1980s and at the beginning of the 1990s.

Much clearing by large and small landholders is done without the benefit of any subsidy programmes, and probably one half of the clearing has been carried out without incentives [94]. Clear land (land without trees and roots) is 50 per cent more valuable than land with untouched native vegetation. This stimulates the acquisition of low-cost land, which is cleared and sold at a higher price.

In areas where charcoal markets exist, land-clearing is further encouraged by the opportunity to make money also from the production and sale of charcoal, instead of just burning the vegetation without recovering any of the costs associated with deforestation. This is quite common in the states of Amazonia (Goiás, Mato Grosso, Tocantins) where it is feasible to export charcoal to Minas Gerais, the major pig-iron production centre. Charcoal is transported by truck over distances in excess of 600 kilometres.

Measurements were recently carried out at a farm near Brasilia, over a two-year period, to establish an energy balance for the transformation of native vegetation to pasture [95]. As shown in figure VI.2, from a total of 173 x 10^{10} joules per hectare of native vegetation and 387 x 10^{10} joules per hectare of underground biomass and carbon in the soil,* 112 x 10^{10} joules per hectare were used as raw material for charcoal, 1.3 x 10^{10} joules per hectare were lost to erosion, and 208 x 10^{10} joules per hectare were lost to decomposition. The new benefited area still has a reasonable amount of energy (energy content of the soil from organic residues and ashes) to support the next vegetation. Measurements carried out over a longer time span could identify further carbon losses resulting from mineralization of organic matter [96], which is not accepted by other authors [97, 98].

2. *Agribusiness*

Agribusiness accounts for a small portion of the cleared area relative to pasture, but one that could expand significantly. Large forestry activities were planned in the 1980s, including a plantation of 2.4 million hectares of Eucalyptus for charcoal production and a charcoal collection system to meet the large pig-iron demand of the Çarajás Project in Amazonia [87]. The Carájas Project has slowed down, and charcoal production is currently small compared with production at the traditional pig-iron centre of Minas Gerais (in 1991 the merchant pig-iron produced at Carajás and Minas Gerais accounted for 5.3 per cent and 89.6 per cent, respectively, of the total Brazilian production [99]).

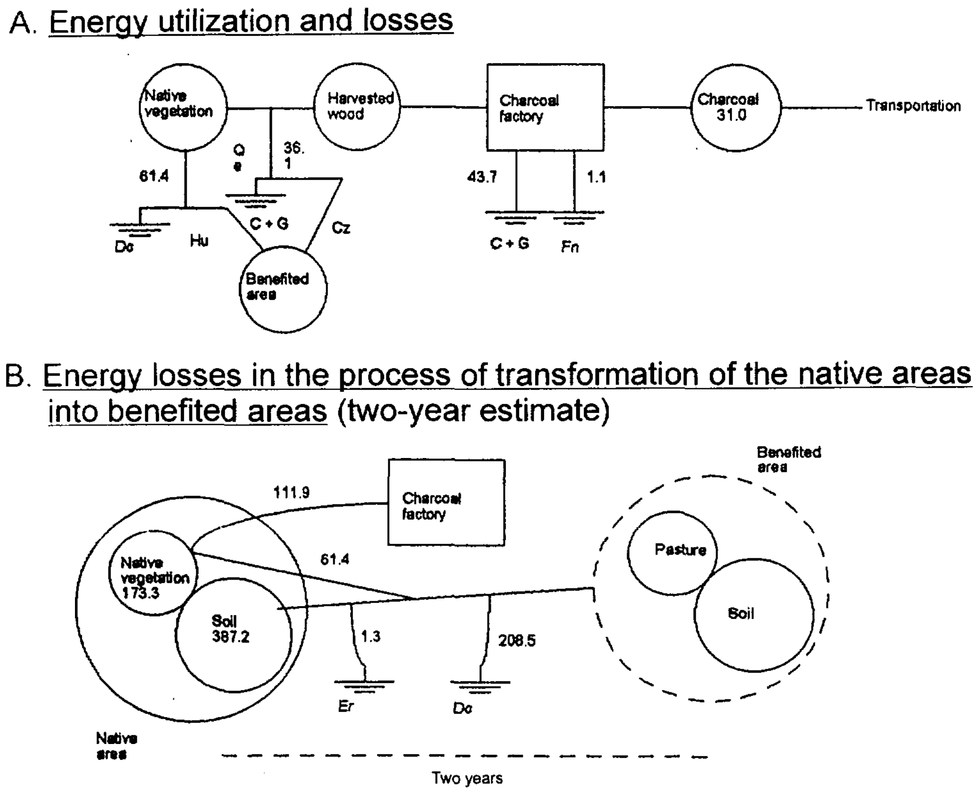
3. *Perennial crops*

Investments were made with the purpose of exploiting some crops like cocoa, coconut, palm oil and black pepper, but on a very small scale relative to the land potential. The total extension of palm-oil crops in the Amazon region is only 70,000 hectares. Nevertheless, its production cost is low compared with average international prices. Brazil is a net palm-oil importer, owing to the current cost of money,

*The measurement was carried out for an average land area of Brazilian savannah, and it showed that above-ground biomass was 819 grams per square metre per year and below-ground biomass 1,131 grams per square metre per year.

which makes it unfeasible to invest in projects that take 5 to 7 years for the first return. Also, diseases curtail the potential for conversion of large areas to perennials. Black pepper and palm oil suffer from farm diseases that have followed them from the continents in which those crops originated [87].

Figure VI.2. Destination of energy stocks in the production of charcoal from wood reserves



Source: G. C. Abdala, "Analise energetica de um cerrado e sua exploracao por atividade de carvoejamento rustico", Master of Science thesis, University of Brasilia, Brasil, 1993.

Notes: Er = erosion; Fn = charcoal fires; Qe = field fire; C + G = heat and gases; Cd = decomposition; Hu = humification; and Cz = ashes. Units are in 10^{10} joules per hectare.

4. Lumbering

Lumbering is rapidly increasing in importance as a factor in Amazonian deforestation. Timber exploitation had, in the past, been much less prominent in Amazonia than in tropical forests of Africa and South-East Asia because of the lower density of commercially valuable trees in South America. Decimation of the tropical forests in Africa is essentially complete from a commercial standpoint, and those of South-East Asia are rapidly nearing a similar end. Exports from Amazonia are therefore increasing. Timber removal from Amazonia has occurred through rapid proliferation of small sawmills in Mato Grosso, Rondonia, Acre and Roraima.

Lumbering in the uplands is destroying stocks of some of the most valuable species, including *cerejeira (Amburana acreana)* and *mogno (Sweitenia arophylla)*. Processing and logging is done by large firms and by thousands of relatively small Brazilian operators; half of the logging activity is believed to take place in clandestine operations, outside the control and tax-collection efforts of the Brazilian Institute of Forestry Development [87].

The cutting of noble hardwoods is spreading rapidly. Less noble woods are also increasingly finding markets. Efforts continue to develop ways of using more of the diverse forest species. The possibility exists for an entire forest to be simply uprooted and shipped away for the manufacture of chipboard or low-quality paper products. A particular chipboard factory in the State of Amapa has an installed capacity of 900,000 tonnes per year, and most of the production is exported [100].*

The use of wood chips for fuelling thermoelectric plants is another possible contributor to deforestation. Because of the lack of modern technology and the small electricity demand in most cities in the Amazon region, such initiatives (like that of Manacapurú in Amazonas and Ariquemes in Rondonia) did not succeed. Even in the case of Ariquemes, where a 14-MW plant has been operating for a few years, the fuel is almost all sawmill and land-clearing residues, with no value for the seller [100]. With the possibility of more efficient initiatives and the use of modern technology like biomass gasification (see chapter III, section B), the risk of deforestation may return.

5. Slash-and-burn

Slash-and-burn pioneer agriculture has long been a major factor in the Amazonian portions of Peru and Ecuador, but has been overshadowed in Brazil by the rapid increase of pasture on large ranches. The importance of slash-and-burn to large ranchers is increasing because of the shortage of funds for financing ranchers and because of the increasing expulsion of small farmers from southern Brazil [87].

All the activities described above have been slowed down, but have not ceased. Simply outlawing deforestation is completely ineffective, as has been demonstrated in Brazil by the unenforced Forestry Code (decree law number 4771 of 15 September 1965) limiting clearing to 50 per cent of any property and the 1986 law (decree law number 7511 of 7 July 1986) prohibiting deforestation completely.

In response to the tremendous need for change, Brazil has made advances in protecting its natural ecosystems and incorporating environmental factors into development procedures. Today Brazil has a Ministry of the Environment, a system of national parks and a law requiring an environmental impact report prior to approving any major development project. The legal and legislative advances in protecting the environment must be further strengthened by building a corps of qualified people to carry them out [87]. Currently, very few areas of the Amazon region are under forest management. Since 1980, five projects have been identified [101], covering less than 300 hectares.

6. The forest as a carbon sink

Increasing the carbon pool focuses on increasing the amount of carbon stored in vegetation (live and dead, above- and below-ground biomass), soil (oxygen and mineral levels) and durable products. Increasing the carbon pool in vegetation and soil can be accomplished by protecting secondary successional forests and other degraded forests whose biomass and soil carbon densities are less than

*The factory has 82,000 hectares reforested with pines on a 180,000-hectare farm, having started industrial operations at the beginning of 1993. It produces wood chips which are exported to cellulose industries. During processing, large amounts of bark and other wood residues are generated.

their maximum value, and by allowing them to sequester carbon by natural or artificial regeneration and soil enrichment. Total deforestation in the Amazon forest has reached 25 million hectares [85], and assuming that reforestation would be able to restore the same amount of carbon lost (0.1 picogram per 1 million hectares), it is possible to absorb 10 picograms of carbon. Man-made forests using fast-growing trees are able to store carbon until they reach an equilibrium in one or two decades. A major reforestation programme has been proposed for Brazil, but is designed for areas outside the Amazon region [102].

C. Technologies for the use of round wood

In the Amazon region, most of the forest biomass is being used for logs (37.8 million m^3 per year), followed by woodfuel (10.8 million m^3) [36]. Charcoal and pulp and paper use is much smaller (0.7 and 1.2 million m^3 per year). Considering the deforestation rate of 0.3 per cent for the last few years [85] and the full extension of 4 million square kilometres, annual deforestation is 1.2 million hectares per year. Assuming a forest density of 200 tonnes per hectare, as much as 240 million tonnes (approximately 400 million m^3) of round wood is being cut every year, of which less than 20 per cent is utilized.

Given this excess wood supply, inefficient technologies must be applied in most cases. A few attempts have been made to use the wood for electric power generation. Examples are provided by a thermoelectric plant at Ariquemes, owned by a private entrepreneur, and the well-known Jari unit. For the operation of the large Jari pulp factory, a 55-MW thermoelectric plant consuming 2,000 tonnes per day (on a dry basis) of wood chips was constructed. For the operation of a 14-MW SATHEL thermoelectric plant at Ariquemes, 3 kg of wet wood residues per KW-hour (2,000 kilocalories per kg) is used. Assuming a heat value of 5,000 kilocalories per kg of dry wood, Jari consumes 10,000 gigacalories to produce 1,000 gigacalories of electricity, and the Ariquemes unit consumes 7 megacalories to generate 1 megacalory of electricity. Modern steam-condensing turbines can work with efficiencies of 20-30 per cent, depending on their size.

The official plan of the electric power industry (Plan 2015) forecasts the use of modern technologies [58]. The plan calls for biomass from planted forests to be gasified, and the gas, after cleaning, will be used in gas turbines running in single-cycle, combined-cycle (with steam turbine) and steam-injected gas turbines (STIG). Cost estimates for electricity generation range from $44 to $78 per MWh for a single-cycle unit, $41 to $69 per MWh for a combined-cycle unit and $38 to $66 for STIG [58]. The cost uncertainties are caused by interest rates, costs of wood from planted forests ($1.5 to $3.5 per gigajoule) and turbine and gasifier efficiencies.

Charcoal is also produced at half the potential efficiency achieved in south-east Brazil, since it is mainly produced by individuals as opposed to the large installations in the State of Minas Gerais.

It is clear to entrepreneurs that for large-scale production of energy to be a profitable business, they must grow their own plantation and depend on less than 50 per cent from external suppliers [103]. Wood prices from forest plantations are regularly published for some states [104].* Estimated costs as high as $45 per tonne are given for woods obtained from high-value land, but most costs are around $15 per tonne, or $1 per gigajoule for reasonably valued land and for eucalyptus plantations in the less developed regions of Brazil [61]. For this value a thermoelectric plant of reasonable efficiency (30 per cent), can produce electricity at a cost of $11.5 per MWh, considering only fuel costs. After adding investment costs, operational cost and taxes, sales of electricity at $60 per MWh produce a reasonable profit.

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*During 1994, in the State of São Paulo, prices varied from $20 to $40 per tonne delivered to destinations up to 300 kilometres away.

Electricity prices in Brazil were uniform until recently, and even today they are very similar for all regions. In the isolated areas, electricity is generated mainly from thermal sources and the final delivered cost is as high as $160 per MWh, being covered by subsidies. It is, therefore, clear that the limited use of biomass for electricity production is due to barriers other than prices.

Usually private entrepreneurs are not familiar with the potential of biomass, or they do not want to invest since they must sell the electricity through existing distribution networks that are the property of State-owned utilities. Those utilities have their own generation systems, and do not facilitate competition. In cases where the utility has a stake in the undertaking, the risk of not being by them paid on time is another obstacle.

In the developed part of the country, there are no independent power producers, with the exception of a few sugar-mills, because they must sell electricity to the grid at low prices.*

As a consequence of all the economical and institutional barriers, no motivation exists for investment and use of high technologies** for biomass-based electricity generation.

There is currently some surplus electricity (2,000 MW) as compared with total consumption of 35,000 MW. The predicted shortages and lack of public money for investment may, however, present significant opportunities for private entrepreneurs interested in thermal generation.***

With regard to wood used for the manufacture of plywood and cardboard, in home construction and particularly in furniture, there is room for improvement in product quality through the use of better technology. Almost none of the wood used for such purposes is dried in a closed environment, under controlled temperature and moisture levels [103]. The use of better technology can reduce wood waste, thus reducing the pressure to continue deforestation. The actions of importing countries may have a significant effect on this line (see box).

Trade-related environmental measures and green consumers

In recent years, trade-related environmental measures (TREMS) have been adopted with increasing frequency. TREMS are customs and non-customs barriers established for the purpose of reducing environmental degradation [107].

Environmental issues cover two major categories. One deals with forest management and the other with the transformation industry and final product use. One of the major reasons for the growing utilization of TREMS has been the efficiency of the General Agreement on Tariffs and Trade (GATT) and its successor, the World Trade Organization (WTO) [107].

Many developed countries, reacting to public opinion, are imposing barriers on imports of round wood from tropical countries. Such a decision is perceived by the round-wood-exporting countries as a discriminatory measure in favour of countries of the North. The International Tropical Wood Organization is studying proposals, and the major argument presented by tropical countries is that cattle-ranching and agriculture are the major cause of deforestation, mainly in South America [108]. Even in the producer countries, the pressure of internal and external public opinion is increasing concern about deforestation, and actions such as issuing certificates for forest products are under way to promote better management practices.

*Electricity is valued at $40 per MWh or even less, since it has to compete with hydroelectric dams tied to the interconnected system.

**Technologies like those of high-pressure (above 60 kg per square metre) steam turbines, coal and biomass co-firing and gas turbines [47] are well known in the country.

***Initially, natural gas will be the cheapest alternative, but the gas production of the country and imports from neighbouring countries are limited.

D. Future prospects

Since 1965, in the southern and south-eastern parts of Brazil, many plantations have been successfully established. As shown elsewhere [42], as much as 3.90 million hectares of fast-growing trees (1.6 million hectares for coniferous and 2.3 million for non-coniferous trees) were planted, amounting to 15 per cent of the total world industrial plantation of fast-growing trees. Another estimate is that, as of 1986, there were 6.2 million hectares of plantation in Brazil, of which 3.45 million were eucalyptus and 1.86 million were pines [105]. Besides the need for traditional forestry products (lumber, plywood, pulp and paper), in Brazil there is also a need for charcoal for use in the iron and steel industries.

Improvements in soil preparation, planting, cultivation methods, species selection and vegetative propagation through clonal techniques and pest, disease and fire control have all contributed to significant increases in average yields per hectare over the past two decades [42]. Large commercial plantations in the States of Minas Gerais and Bahía have achieved average yields in the range of 30 to 44 m^3 per hectare per year, as shown in table VI.1.

The Hydroelectric Company of San Francisco (CHESF), a federally owned utility responsible for the generation and transmission of electricity in the north-east, is looking at the possibility of electricity generation from plantation wood. A major assessment of the prospects for large-scale production of biomass for energy has been carried out [106]. The assessment showed that plantations could be established on about 50 million hectares (one third of the land area of the north-east), at an average productivity of 12.5 dry tonnes of harvestable material per hectare per year. If that much biomass were used solely to generate electricity with an advanced biomass integrated gasifier/gas turbine, it could provide some 1,500 TWh of electricity per year, six times the total generated in all of Brazil in 1990 [106].

The average plantation yields estimated in the CHESF study are considerable less than yields routinely achieved in the south-east, largely because biomass production is affected by water shortages in most parts of the north-east [42]. In 1989, estimated costs of plantation wood from commercial eucalyptus were $8.58 per dry tonne for stand-up wood and $17.85 per dry tonne at the electricity plant [109], yielding a value of $2.2 per gigajoule at 6 per cent interest rate and 2.4 per gigajoule at 12 per cent interest rate. Even considering such costs as minimum values, much better conditions for eucalyptus plantation are available in more water-rich areas of the country. There is clearly enormous potential in planted forest as a source of energy.

Table VI.1. Data for selected commercial eucalyptus plantations in Brazil

Company	Location	Planted area (square kilometres)	Average temperature (Celsius)	Altitude (kilometres)	Annual precipitation (millimetres)	Rotation time, in years	Yield peak (solid cubic metres per year)	Yield average (solid cubic metres per year)
CAF	Bom Despacho Minas Gerais	300.0	22	0.70	1 375	4.4	50.3	44.0
CAF	Carbonita Minas Gerais	250.4	21	0.73	1 025	6.0	24.5	21.0
Floresa	Vale do Jequitinhonha Minas Gerais	1 000.0	24	0.73	1 025	4.4	37.6	31.8
Copener	Inhambupa Bahía	180.5	24	0.20	900	6.0	-	30.0
Copener	Alagoinhas Bahia	80.6	24	0.20	1 100	6.0	-	30.0
Copener	Entre Rios Bahía	130.9	24	0.20	1 100	6.0	-	40.0
Cimenta-Nassau	Barbalha Ceará	10.2	21	0.90	650	7.0	-	14.7

Source: A. E. Carpentieri and others, "Prospects for utility-scale, biomass-based electricity supply in north-east Brazil", report No. 270 of the Center for Energy and Environmental Studies (Princeton, New Jersey, Princeton University Press, July 1992).

VII. OTHER BIOMASS ENERGY USES

A. Anaerobic fermentation

Sugar-cane stillage (vinasse) is by far the most significant liquid effluent in terms of polluting potential in the State of São Paulo. Vinasse has biochemical oxygen demand (BOD) values in the range of 6,000 to 25,000 milligrams of oxygen per litre, and is produced in large amounts (12 to 13 litres per litre of ethanol). During the early years of PROALCOOL most vinasse was directly discharged into open water systems. Nowadays most of it is returned to the field as part of an integrated irrigation and fertilization system, the remaining fraction being kept in ponds for aerobic fermentation.

Considering its large amount, vinasse could technically be used for biogas production in anaerobic biodigestors, using the organic parts of the effluent. There is one distillery in the State of São Paulo using a biodigestor, processing only one third of its vinasse for biogas production. The whole truck fleet of the distillery can run on the biogas produced. Large-scale implementation is deterred by the low profitability resulting from the low cost of diesel fuel [110].

The biogas produced by the anaerobic digestion of vinasse can be used in boilers to generate steam or electricity, in gas turbines or as a diesel substitute. The energy potential of the anaerobic treatment of vinasse is significant, and can increase the overall energy output of plants yielding sugar and alcohol. As shown in table VII.1, vinasse represent 7.3 per cent of the energy balance of a distillery.

Table VII.1. Simplified energy and mass balance of autonomous distillery

Product per tonne of cane	Energy value (megacalories)	Share of energy output (percentage)
250 kg of bagasse (1,800 kilocalories per kg)	450	49.5
70 litres of ethanol (5,600 kilocalories per litre)	392	43.2
1,000 litres of vinasse (equivalent of 7.5 cubic metres of methane) (8,800 kilocalories per cubic metre)	66	7.3

Source: P. Zandbergen, "Energy and environmental policy in Latin America: the case of fuel ethanol in Argentina and Brazil", thesis of Master of Sciences", (Enschede, Netherlands, University of Twente, June 1993).

On the basis of the quoted values, it is possible to generate 620 MW of electricity during the six months of the sugar-cane harvest, or displace 0.8 million m^3 of diesel per year. Another estimate indicates that 1,000 MW could be generated during 6 months [111].

Another energy account shows that if an efficient gas turbine for electricity generation (40 per cent efficiency) is used, the biogas from vinasse can produce 31 kWh and 66 kg of steam per tonne of sugar cane. This is enough to provide all the electric needs of the distillery (14 kWh) and 16 per cent of its total steam requirement (400 kg per tonne of cane). Molecular sieves can reduce distillation requirements to 300 kg per tonne of cane, which shows how significant is the utilization of biogas and modern technologies [112].

B. Thermochemical gasification

Biomass gasification has been carried out in Brazil for a long time. A particular company produced more than 100 charcoal and wood gasifiers, with capacities up to 5 gigacalories per hour [113]. Nevertheless, the quality of the gas produced was always poor (excessive amounts of tar and particulate), and the gasifiers were mainly used to produce thermal energy. The very few attempts made to run diesel engines had limited success.

C. Biomass briquettes

Briquettes made of wood and crop residues have been commercialized in Brazil since at least 1990. In the State of São Paulo alone, an evaluation performed in 1991 identified 22 producers, with 37 pieces of equipment installed. The installed capacity at that time was 11,000 tonnes per month [114]. The current estimated capacity of commercial installations is above 30,000 tonnes per month, of which 20,000 tonnes are used by the commercial sector (bakeries and pizzerias) and 10,000 tonnes by the industrial sector [115].

Most of the briquettes are made from sawdust and other wood-processing residues (from installations such as toothpick factories, pencil factories and sawmills). Residues from cotton and rice crops are also used on a much lower scale [115].

Efforts have been made to use sugar-cane bagasse, but with little success. Even when dried sugar-cane bagasse pellets (moisture content of 20 per cent) made by BAGATEX and commercially available until 1994 were used, the briquette machine presented operational problems. The optimum moisture content is 10 per cent, and the highest level for trouble-free processing is 15 per cent. Some success was achieved when specially treated bagasse was mixed with sawdust, but the resulting product was too expensive [115].

The total consumption of briquettes in the State of São Paulo is higher than the production capacity, and consequently, briquettes are imported from the States of Paraná and Santa Catarina. In 1991, 2,000 tonnes per month were imported. It is currently estimated that 6,500 tonnes per month come from other states to São Paulo [115]. During 1991, 60,500 gigacalories of energy from briquettes were consumed in the State of São Paulo alone. This is equivalent to 6 per cent of the total firewood consumption and 35 per cent of the firewood consumed in the food and beverages industry, which is the major industrial user of biomass for energy. The briquette energy contribution today is even higher.

The major appeal of briquettes is their high energy content (5,500 kilocalories per kg) as compared with firewood (3,300 kilocalories per kg) and their high density (0.96 grams per cubic centimetre compared with both firewood (0.39 grams per m^3) and charcoal (0.25 grams per m^3). Product homogeneity and its low storage space requirements make its market value of $60 per tonne quite attractive. Such a price is equivalent to that of fuel oil, with the added advantage of zero sulphur emission.

Equipment for briquette-making is either manufactured in Brazil, mainly with technology from Germany, or imported. There are at least three equipment manufacturers, all of them in the southern part of the country.

VIII. CONCLUSIONS

Biomass energy resources are abundantly available in Brazil. Except for a few dry areas, most of the spontaneous biomass growth of the country exceeds current use, which accounts for nearly one third of the energy demand of the country. Nevertheless, the Amazon forest is in danger not because of the amount of biomass used for energy or other products, but because of the removal of biomass from the forest for agribusiness activities, shifting agricultural practices and careless exploitation of a few noble wood species. Also, in the State of Minas Gerais, in areas near the pig-iron industrial centre, non-sustainable use of wood for charcoal production has extinguished almost all tree vegetation, showing that demand has surpassed the supply.

Such negative examples should not be used as arguments against the use of biomass as a source of energy. It is important to distinguish between traditional and advanced technologies for the use of biomass energy resources. The concern with protection of the local environment is growing not only in developed countries, but everywhere, and few opportunities exist for the production of commercial energy from natural forests and native vegetation. Modern technologies, to enhance cost effectiveness, depend on large-scale energy production that can be achieved only through exploitation of man-made forest or biomass crops.

Examples of such modern energy production from biomass are PROALCOOL, the ethanol programme (based on sugar-cane crops), half the charcoal production (based on planted eucalyptus forest) and self-generated electricity and steam in cellulose plants (based on the use of wood residues). A significant amount of energy is being produced in those industries, as reflected in the official country energy profile [9]. Unfortunately, such results do not necessarily mean that energy from biomass will become more important in the future.

Self-sustainable biomass, when used for energy production, can promote development of rural areas, improve the quality of life of the poor, and reduce hard currency expenditures associated with imported oil. It is also one of the most effective means of controlling and even reducing global carbon-dioxide emissions. Even with all those advantages at national, regional and global levels, modern biomass technologies are not receiving the necessary subsidies to compete commercially with fossil fuels. Brazil was the first country to indirectly charge carbon-dioxide taxes to its inhabitants, when the PROALCOOL programme was introduced in 1975. To sustain the large volume of production under the programme, national subsidies of the order of $1 billion per year are being provided. Greenhouse-gas emissions have been reduced, a benefit to all countries.

The participation of other countries, in particular developed countries with advanced technologies and a surplus of capital, is urgently needed, if major recommendations of the Intergovernmental Panel on Climate Change, Working Group II (on impacts and response options), are to be implemented. Outlays of approximately $10 billion for the Brazilian Ethanol Program, which is larger than all the funds of the Global Environment Facility invested thus far, have little chance to be replicated or even sustained, if considered purely in economic terms. Inclusion of externalities in the price composition of fossil fuels and removal of subsidies traditionally supplied are the minimum that is required to preserve biomass competitiveness.

The successful biomass projects are economically uncompetitive with oil, but they are also far from completion and optimization. Ethanol from sugar cane is only one energy product that can be obtained from sugar-cane crops. Sugar-cane bagasse and residues potentially available today can meet half the electricity demand of the country, if capital and high technologies are available. Even with the shortage of funds, technical improvements have resulted in a continuous decrease in the price of ethanol for more than a decade.

Vegetable oil, with the potential to compete technically and economically with diesel oil, needs to be supported by a political decision for massive investments guaranteeing advances of the same kind as those obtained in the ethanol industry, reducing production costs and increasing the possibility of competition with fossil fuels.

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Part two

Romania biomass energy Country study*

Abstract

The present report was prepared under contract to UNIDO to conduct a case study of biomass energy use and potential in Romania. The purpose of the case study is to provide a specific example of biomass energy issues and potential in the context of the economic transition under way in eastern Europe. The transition of Romania to a market economy is proceeding at a somewhat slower pace than in other countries of eastern Europe. Unfortunately, the former regime forced the use of biomass energy with inadequate technology and infrastructure, particularly in rural areas. The resulting poor performance thus severely damaged the reputation of biomass energy in Romania as a viable, reliable resource. Today, efforts to rejuvenate biomass energy and tap into its multiple benefits are proving challenging.

Several sound biomass energy development strategies were identified through the case study, on the basis of estimates of availability and current use of biomass resources; suggestions for enhancing potential biomass energy resources; an overview of appropriate conversion technologies and markets for biomass in Romania; and estimates of the economic and environmental impacts of the utilization of biomass energy. Finally, optimal strategies for near-, medium- and long-term biomass energy development, as well as observations and recommendations concerning policy, legislative and institutional issues affecting the development of biomass energy in Romania are presented.

The most promising near-term biomass energy options include the use of biomass in district heating systems; cofiring of biomass in existing coal-fired power plants or combined heat and power plants; and using co-generation systems in thriving industries to optimize the efficient use of biomass resources. Mid-term and long-term opportunities include improving the efficiency of wood stoves used for cooking and heating in rural areas; repairing the reputation of biogasification to take advantage of livestock wastes and future sanitary landfills equipped with gas collection systems; and developing short-rotation woody energy crops.

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IX. CONTEXT AND BACKGROUND OF THE STUDY

The gap between energy supply and demand in developing countries is anticipated to widen as populations and industrial production continue to grow. The achievement of the economic growth targets of developing countries will probably involve expanded energy production, even with energy efficiency improvements, yet environmental concerns about expanded use of fossil fuels, large hydropower projects and nuclear energy, as well as global issues concerned with the energy trade, threaten to hinder the growth of future energy supplies. Many developing countries have significant biomass energy resources that could contribute to solving those problems.

UNIDO has established an initiative to facilitate dialogue between technologists, scientists, decision makers and potential donors, in order to identify and provide assistance to provide biomass projects. As part of that initiative, UNIDO commissioned a country study of Romania designed to illustrate biomass energy issues and potential in the context of the economic transition under way in eastern Europe.

The objectives of the study are: to identify the potential for development and enhancement of indigenous biomass energy resources in Romania; to establish the resource and market linkages for the acquisition of appropriate technologies to produce marketable products from biomass resources; to identify changes in national energy policies and strategies, as well as institutional linkages, required to realize the biomass energy potential; and to quantify the economic and environmental benefits of the use of biomass resources.

By reviewing the literature, gathering data, conducting interviews in the country and by telephone with key officials, researchers, industry sources and technology suppliers, and talking with international experts in the region, DynCorp assessed the status of biomass resources, patterns of use, and feasible technologies in Romania. By juxtaposing international findings and recommendations with the political, economic and institutional realities of Romania in the 1990s, it was possible to identify areas of greatest potential for biomass energy development and associated economic and environmental impacts. Conclusions and recommendations on the most promising approaches to the further development of biomass energy in Romania are also presented.

X. ROMANIAN SITUATION ANALYSIS

Since the fall of the Ceauşescu communist regime in 1989, Romania has been undergoing dramatic economic transition, though somewhat slower than that of other countries of eastern Europe. In an effort to move toward a market economy, the country is implementing a reform programme including price liberalization, redefinition of the role of government and the privatization of agriculture and State-owned companies. The Land Law (law 18/1991) returned state lands to previous owners. The Law on the Restructuring of State-owned Companies (law 15/1990) states that all State-owned enterprises in Romania should be transformed into either joint-stock or limited-liability companies ("commercial companies") that will be entirely privatized, or into autonomous administrations (*régies autonomes*) that will remain under State control.

After significant downturns in all sectors of the economy in the early 1990s, a positive 1 per cent growth in GDP was achieved in 1993, followed by 3.4 per cent growth in 1994. Prior to 1989, heavy industry was the focus of domestic economic activity, but growth in the past few years is attributed largely to the agriculture and service sectors, with modest growth seen in industry. From 1996 to 2000, GDP is expected to grow at about 5 per cent per year, with agriculture and services as the leading sectors [1].

Romania is endowed with substantial indigenous energy resources. Compared with other non-OECD countries in Europe,* Romania's total primary energy supply as of 1992 was second only to that of Poland. Romania, both today and historically, significantly surpasses all those countries in crude oil and marketed natural gas production. Romania also depends heavily on its indigenous coal resources, particularly lignite. Table X.1 shows current Romanian fossil fuel reserves and production [1, 2]. Among the same group of countries, development of hydropower in Romania is exceeded only by that of the former Yugoslavia [3], with 12 TWh per year already developed in Romania and a potential of 40 TWh remaining. In addition, the commissioning of the first 700-MW unit of the 3,500-MW Cernavoda nuclear power plant was scheduled for December 1995 [1]. The renewable energy resources of Romania, not including hydropower, supply less than 1 per cent of the primary energy needs of the country [4].

Table X.1. Romanian fossil-fuel reserves and production

Fossil fuel	1995 reserves	1994 production
Natural gas, billion m^3	517	19.6
Probable	200	..
Crude oil, thousand tonnes	200,000	6,737
Probable	100,000	..
Coal, thousand tonnes		40,547
Lignite	1,000,000	..
Hard coal	500,000	..

Sources: World Bank, "Romania: power sector rehabilitation and modernization project", Staff Appraisal Report No. 13887-RO (Washington, D.C., August 1995); and National Commission for Statistics, *Romania in Figures* 1995 (Bucharest, September 1995).

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*Albania, Bulgaria, Cyprus, the former Czechoslovakia, Hungary, Poland, Romania and the former Yugoslavia.

Over the past decade, however, Romania has seen steadily declining production of fossil fuels. Once a fairly important oil exporter, the crude oil output of Romania dropped by 37 per cent from 1976 to 1989, while natural gas production fell by 42 per cent from 1984 to 1993, primarily as a result of deteriorating and inadequate production and supply infrastructure. No reversal in the trend has been seen to date, but current plans are to open up the domestic oil and gas sector to foreign investors. Still, Romania now faces increasing dependence on imported energy resources [5].

A. Electricity and heat production

The Romanian Electricity Authority (RENEL) supplies 96 per cent of all electricity generation (importing only 1.3 per cent of that amount in 1994), while the balance is generated by self-producers. RENEL operates a monopoly in electricity transmission. In 1994, the industrial sector accounted for 56 per cent of net consumption of electricity supplied by RENEL, with agriculture, services and others consuming 14 per cent, households 13 per cent, and transport and telecommunications 4 per cent. Table X.2 shows a matrix of electricity and heat supply and consumption as well as tariffs as of June 1995 [1, 6].

In 1993, 61 towns in Romania had district heating systems, 32 of which were supplied by RENEL plants. The majority of district heating systems are supplied by heat and power co-generation plants owned by either RENEL or industry, and the rest are supplied by thermal power facilities owned by RENEL, industry or municipalities. RENEL supplied 40 per cent of the total (649 petajoules) delivered heat in 1990 for industrial processes and space and water heating, with about half going to industry and the rest to agriculture, forestry, residential and public district heating [4]. In 1994, the district heating supply of RENEL continued to fall as it had over the past four years to 173 petajoules, with only household heat consumption rising during this period and remaining above 1989 levels [6]. Estimates of thermal energy supply in 1995 show RENEL continuing to supply about 38 per cent of the total, with municipalities and self-producers supplying the balance. Heat demand is not expected to reach 1990 levels again until after 2005 [1].

B. Fuels

Table X.3 shows a matrix of selected consumers of Romanian energy resources in 1992. The table illustrates the extensive use of natural gas and coal for both electricity and heat production by public facilities. Coal is the second most-common fuel in combined heat and power plants, suggesting that in-country experience with solid fuel co-generation is extensive, and could facilitate the development of biomass co-generation. In 1991, the profile of residential sector consumption was 59 per cent district heat, 30 per cent gas, 7 per cent electricity, 2 per cent oil and 2 per cent coal [3].

C. History of production and use of biomass energy in Romania

Romania has a strong history of biomass research and utilization stemming from efforts under the previous communist regime. As a result of the oil price shocks of the 1970s, significant efforts were directed towards alternative energy sources. The Government of Romania supported research and development efforts in biomass and other renewable energy sources through numerous government research institutes. A major government policy under the Ceauşescu regime that had a direct effect on biomass energy, called systematization, was aimed at moving rural village populations into larger towns and city centres and making agricultural centres self-sufficient. In line with this, farms were expected to supply their own energy, and thus anaerobic digestion of animal manure to produce biogas (methane) and the use of other biomass resources became major initiatives.

Table X.2. Electricity and heat supply and demand matrix, Romania (1994)

	Consumption					
Supply sources	Industry	Agriculture and construction	Transport and telecommunications	Commerce and services	Residential	Total
Electricity						
RENEL energy, TWh	29.4	2.7	2.0	2.6	6.6	43.3
Industry energy, TWh	1.5	..	..	..	..	1.5
Total	30.9	2.7	2.0	2.6	6.6	44.8
RENEL tariffs, dollars/kWh, June 1995	..[a]	..[a]	..[a]	..[a]	2.4	-
Heat						
RENEL heat, petajoules	76.8	27.4	..	..	68.8	173
Industry and municipal heat, petajoules	..	..	..	..	..	282[b]
Total	..	..	..	..	..	455[b]
RENEL tariffs, dollars/Gcal, June 1995	19.0	19.0	19.0	19.0	7.3	-

Sources: .World Bank, "Romania: power sector rehabilitation and modernization project", Staff Appraisal Report No. 13887-RO (Washington, D.C., August 1995). RENEL, *Annual Report 94* (Bucharest, March 1995).

[a]Between 4.6 and 6.7 dollars per kWh.

[b]Estimate based on RENEL supplying 38 per cent of heat energy in Romania in 1994.

Table X.3. Romanian energy balance, in 1992
(Thousand tonnes)

Item	Coal	Petroleum products	Gas	Hydropower and other	Electricity	Heat	Crude oil	Total
Total primary energy supply	10,593	-752	18,964	1,034	361	--	12,564	42,764
Losses, statistical differences, processing	1,531	-11,627	13	--	7,781	-8,458	12,564	-13,758
Public electricity	860	106	1,465	1,030	--	--	--	3,461
Self-producers	37	8	47	4	282	--	--	378
CHP plants	5,972	2,719	6,462	--	4,379	3,948	--	23,480
District heating plants	369	9	3,681	--	--	298	--	4,357
Industry	1,003	1,001	4,887	--	2,192	1,517	--	10,600
Food and tobacco	4	134	124	--	122	--	--	384
Paper, pulp, printing	--	7	15	--	76	--	--	98
Wood and wood products	1	10	14	--	34	--	--	59
Construction	1	171	15	--	57	--	--	244
Other	997	679	4,719	--	1,903	1,517	--	9,815
Transport	5	4,611	10	--	242	21	--	4,889
Other sectors	802	1,439	2,398	--	1,046	2,674	--	8,359
Agriculture	3	884	37	--	188	268	--	1,380
Commercial and public services	--	--	--	--	--	--	--	--
Residential	389	461	2,361	--	653	2,331	--	6,195
Non-specified other	410	94	--	--	205	75	--	784
Non-energy use	13	975	--	--	--	--	--	988
Total consumption	**10,592**	**-759**	**18,963**	**1,034**	**360**	**--**	**12,564**	**42,754**

Source: Organisation for Economic Co-operation and Development, *Energy Policies of Romania: 1993 Survey* (Paris, 1993).

Note: Differences in total primary energy supply and total consumption is due to rounding.

In the rush to develop renewable energy systems, however, feasibility studies were inadequate or simply not performed, and ultimate system performance was poor and unsatisfactory to the users. As a result, a strong bias against biomass exists in Romania, most of the population associating it with experiences under the Ceauşescu regime. Government officials report that while new technology development was supported and widely publicized, technological advancement languished because of insufficient funding, and today receives minimal government support for completing the development needed to bring the technologies to commercial scale. Currently, with energy shortages due to deteriorating energy production infrastructure and amidst continued economic crisis, government priorities are focused on larger-scale primary energy sources (nuclear energy, fossil fuels and hydropower) and general economic recovery [7].

Biomass research and development efforts are continuing on a limited scale, however. The most significant current initiative is the project sponsored by PHARE* to develop a renewable energy strategy for Romania. Under this programme, a consortium of consultants and in-country specialists and researchers are working together to develop a strategy that will include estimates of the biomass energy potential in the country, suggested pilot projects, as well as recommendations for addressing legal, institutional, and financial issues affecting the development of biomass and other renewable energy sources [7].** The present report incorporates many critical insights and information from Romanian participants in the PHARE initiative, and helpful input based on a review of the preliminary draft of the PHARE strategy document.

Other recent biomass energy research efforts include two projects in coordination with countries of western Europe. The first, completed in May 1993, was a cooperative effort of the Energy Research and Modernizing Institute of Romania and the Institute for Renewable Energy (CIEMAT) of Spain. The study examined the development of a prototype for biomass co-generation using an atmospheric fluidized-bed boiler with a Stirling engine. The second project, completed June 1995, involved ICEMENERG and the national electric utility of Italy, ENEL. The team estimated biomass quantities and qualities in Romania, and researched their chemical analysis, caloric value and other factors [8].

A study carried out by the Commission of the European Communities in 1991 compared the electric and thermal energy produced from renewable energy technologies in six countries of eastern Europe, including Romania. At that time, biomass did not fuel any electrical capacity in the region, but Romania was second only to Poland in the production of heat from biomass fuels (see table X.4) [9].

Table X.4. Biomass energy contribution to heat in six eastern European States, 1990

Country	Heat (thousand tonnes of oil equivalent)
Poland	1,425
Romania	863
Czechoslovakia	620
Hungary	407
Bulgaria	338
Yugoslavia	..

Source: Commission of the European Communities, *The European Renewable Energy Study* (Brussels, 1991).

*PHARE is a cooperation programme between the European Union and States of eastern and central Europe providing significant support for the energy sector and environmental protection.

**The final report was to be issued by the PHARE programme in December 1995 or January 1996.

XI. CURRENT PRODUCTION AND USE OF BIOMASS RESOURCES

Currently, biomass resources are not used in any electric generation facilities or any district heating systems in Romania. Biomass resources are, however, important fuels for the residential and industrial sectors, providing fuel for cooking and space heating in rural homes, and steam, hot water, process heat and space heating for industry. The following six biomass resource categories are described below, including estimated availability, current use and potential enhancement opportunities: forestry residues; wood-processing-industry residues; agricultural crop field residues; energy crops; livestock wastes; and urban waste.

Table XI.1 shows estimated current biomass resource availability and use, as well as projected energy potential.

A. Forestry residues

Wood resources are the most promising biomass resources available to Romania, and account for the largest share of current biomass energy production. Residues from forestry operations provide fuelwood for both rural communities and industry.

The forested lands of Romania are distributed as follows: sixty per cent of forests are in mountainous regions; thirty per cent of forests are in hilly regions; ten per cent of forests are in the plains regions.

Figures XI.1 and XI.2 depict counties of Romania categorized by total forested lands and topography. A comparison of the two maps shows that the counties with the greatest forested area are also those with the steepest terrain located in the eastern Carpathian Mountains and the south-western portion of the Transylvanian Alps.

Today, State-owned forests, managed by the State company ROMSILVA, comprise 94 per cent of the total forest area of Romania (6.25 million hectares), while 4 per cent is owned through commons or cooperatives, and 2 per cent by private individuals [10]. ROMSILVA manages State-owned forests for the following two purposes:

(a) To establish healthy forests to provide environmental protection. About 2.8 million hectares (44 per cent of the total forest area) are mainly for the protection of water and soil, for countering greenhouse-gas emissions, for social and recreational uses, and for the protection of endangered species and biodiversity (genetic reserves). Of the 2.8 million hectares, 400,000 are off limits to harvesting and are naturally conserved to maintain wildlife;

(b) To obtain high-quality wood for wood-processing industries. ROMSILVA controls harvesting by State and private companies, and also performs "sanitary cuts" (removal of dead wood, diseased trees and windfalls), selling the wood for rural domestic use (fuelwood and construction) throughout its 41 district operations.

Table XI.1. Available biomass resources and use

	Estimated biomass resource use in 1994		Total recoverable biomass resources		Energy potential of recoverable biomass resources	
Biomass type	**Residue (thousand m^3)**	**Thermal energy (petajoules)**	**Thousand tonnes**	**Thousand m^3**	**Thermal energy (petajoules)**	**Electricity generating capacity (MW)**
Forest slash (1994)[a]	4,500	65.250	..	6,000	87.000	803
Wood processing (1995)	830	12.035	..	830	12.035	111
Crop field residue (1994)	..	..	..	..	..	..
Cereals	..	..	5,675	..	99.315	921
Sugar beets	..	..	141	..	2.459	23
Vineyard/orchard	..	..	1,053	..	21.063	194
Prunings	..	..	6,869	..	122.837	1,138
Total[b]	..	..	1,037	..	..	..
Manure (dry weight) (1994)[c]	..	..	..	281,462	6.305	--
Recoverable biogas	--	--	3,168	..	..	..
Urban waste (1994)[c]	--	--	..	9,505	0.002	--
Landfill gas[d]	..	..	..	290,967	6.307	--
Total biogas[b]	--	--	9,028	..	180.566	1,666
Total energy	..	**77.285**	..	..	**402.438**	**3,718**

[a]Total recoverable resource reflects a 15 per cent greater residue recovery from industrial harvesting.

[b]Totals are presented for energy content and electricity generating potential only. Volume and mass of resources are presented for descriptive purposes only; although presented in like units, comparisons of mass and volume of different biomass resources are not valid because of differing energy content. Totals are presented only where comparability and data availability permit.

[c]Thermal energy from biogas only is calculated for livestock and urban wastes, not from combustion of dry residues themselves. Electricity generating capacity is calculated assuming a 75 per cent capacity factor and 23 per cent conversion efficiency.

[d]Annual energy potential of landfill gas is based on continuous disposal of 1994 waste volume in a landfill receiving waste for 10 years.

Figure XI.1. Forested lands

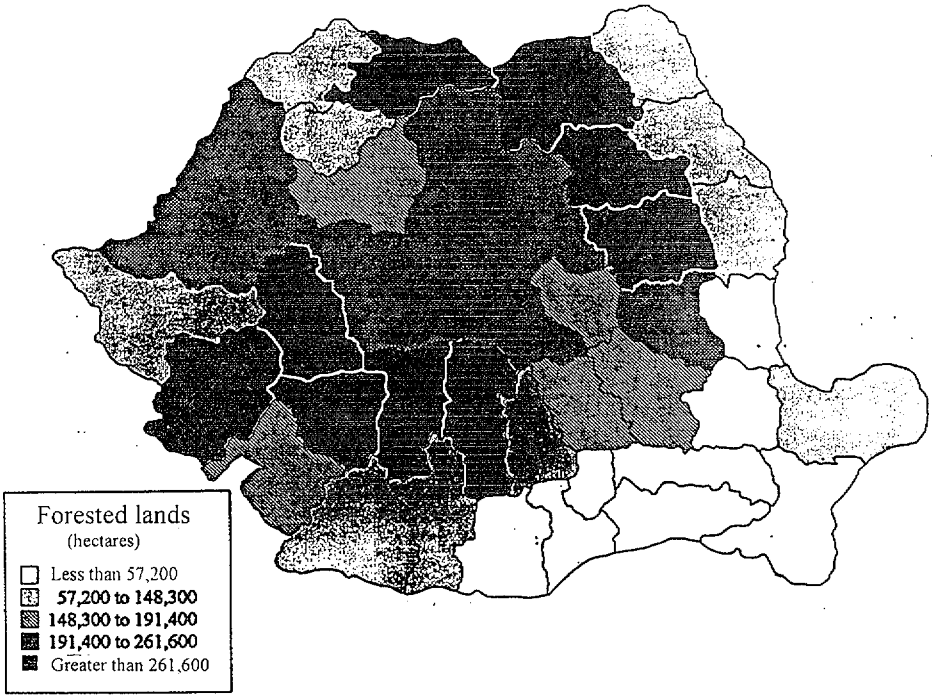
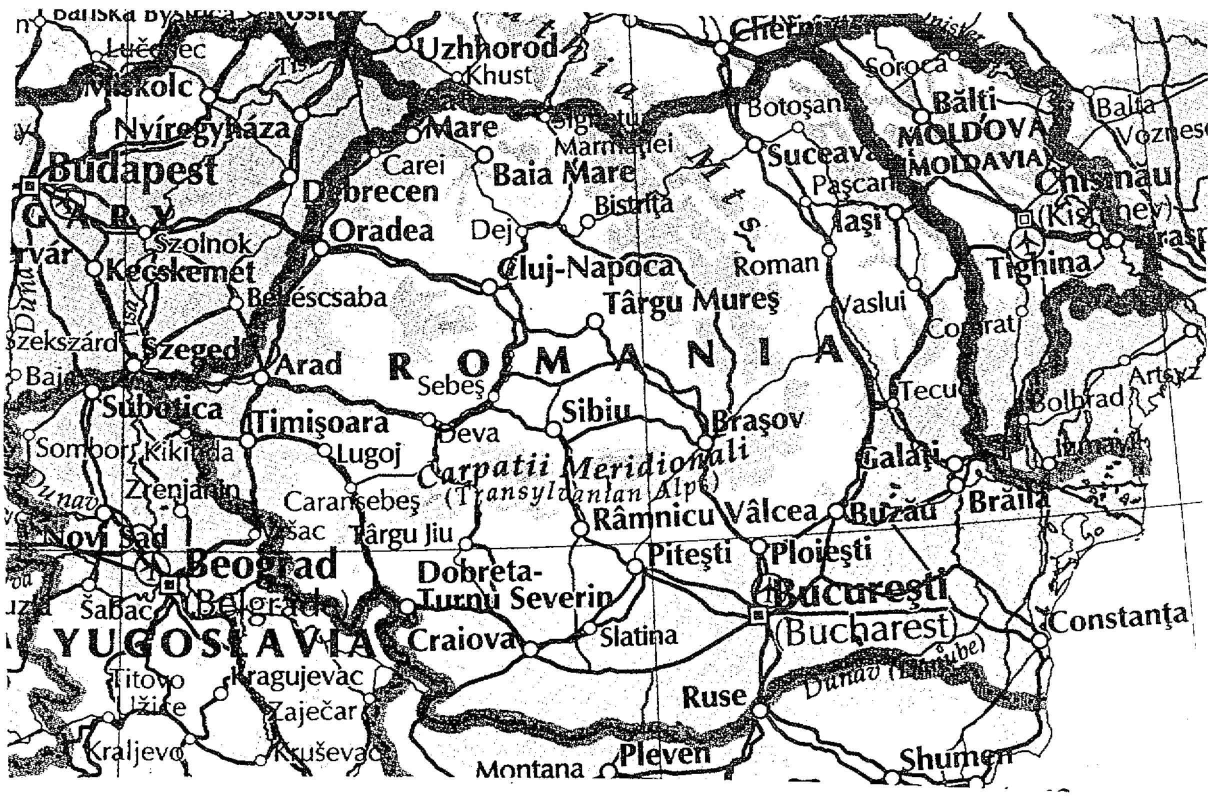


Figure XI.2. Romanian topography



Source: Central Intelligence Agency.

Harvesting companies receive guidelines from the Government on the basis of wood industry strategies, and authorization to harvest from a national commission. Seventeen State companies harvest and transport wood, and about 200 private harvesting companies operate using private capital. All companies participate in the same auction system carried out by ROMSILVA branch offices twice a year [11].

Romanian forests are harvested according to forest management plans and an annual allowable cut approved each year by Parliament. Currently, Romania has 1,350 billion m^3 of standing wood. Forest management plans call for a harvest of from 25 million to 30 million m^3 per year, but because of overharvesting prior to 1990, harvest rates have been decreased to allow the stock to build up. The total annual increment of new wood growth is 34 million m^3, yet only about 14 million m^3 per year are being cut. In 1994, Parliament approved 14.5 million m^3, but only 13 million m^3 were cut, primarily because of inadequate logging roads [12].

1. Current availability of forestry residues

Industry is allowed to extract approximately 10 million m^3 per year of timber from State forests. About 15-20 per cent (1.5 million to 2 million m^3 per year) of this becomes fuelwood (tops, branches etc.). Approximately 4 million m^3 per year of timber are harvested from State forests by ROMSILVA for rural domestic uses such as fuelwood and construction. Of this, an estimated 3 million m^3 per year are used for fuelwood according to ROMSILVA officials [13]. Together, this amounts to an estimated 4.5 million m^3 per year of fuelwood use, approximately equivalent to a potential energy content of 65.25 petajoules.

2. Current use of forestry residues

The main current use of the 4.5 million m^3 per year of fuelwood provided to the rural population is for fuelling small stoves and furnaces for heating and cooking. Those systems are likely to achieve efficiencies of only about 15 per cent.

In mountainous regions or in areas where there is no demand for logging residues, harvesters arrange forest residues (tops, limbs and cull trees) in piles and leave them in the forest. In lower-lying areas with more stable slopes, the wood residues are removed from the forest and sold to the local population. Since harvesting and transport equipment, however, is often inadequate to extract in-forest residues (chippers are virtually unknown in Romania), potential biomass resources are often left in place. The ecological impact on Romanian forests of removing greater quantities of logging residues is as yet unknown [7].

3. Potential enhancement of forestry resources

Currently, logging roads provide access to about 65 per cent of Romanian forests. While other roads may pass through these lands, logging road density is about 6.4 metres per hectare (32,000 kilometres in total), one fifth that of the European average [12]. As a result, about 30 per cent (or approximately 2 million hectares) of the forested area of Romania is inaccessible, defined as being more than 2 kilometres from a road. Areas inaccessible by road have generally not been cut. The planned expansion of forest roads by 20,000 kilometres would raise road density to 9.8 metre per hectare, but budget shortfalls make repairs difficult and the construction of new roads nearly impossible in the near term. The Government has not as yet decided to accept World Bank loans totalling $20 million for forestry investments including road improvements [12]. Planned roads would access all forests, thus increasing the residues potentially available for energy production [13].

A recent World Bank report notes that Romanian forests are managed to maintain a high diversity of species, primarily through natural regeneration and complementary planting of mixed species stands. As of 1995, 21,000 hectares were undergoing either natural regeneration or plantings. Although the Government plans to replant from 20,000 to 30,000 hectares per year, only about 10,000 hectares were replanted in 1993 and 1994, compared with over 41,000 hectares in 1989 and 25,000 hectares in 1991 [12]. The Government takes a very conservative forest management approach, with very light thinnings and long rotations. The high density of forests is of some concern. Though managed in this way for forest land protection, highly dense stands could be more vulnerable to air pollution as tree crowns become thin and short in dense stands [10].

In 1994, a Romanian survey determined that about 35 per cent of all forest species suffered from leaf defoliation, a 60 per cent increase in three years. While adverse climatic conditions were the principal cause, pollution, insect attack, disease and forest fires were also responsible. Integrated pest management efforts are under way on 20,000 hectares of forest land, but experts believe that forest health could continue to decline if industrial pollution is not reduced [12]. This poses a threat to the wood industry, which depends on high-quality domestic timber. Declining forest health may increase the amount of forest slash and cull trees available for energy production, but a decline in the wood industry is likely to result in reduced wood wastes because of less forest harvesting and wood processing. Improving the health of Romanian forests is likely to be the best approach for also enhancing forest residues for energy production.

In view of the above-mentioned limitations on residue removal, if only 15 per cent more residues could be removed by the private harvesting companies than under current practices, the potential energy from managed forests could reach 87 petajoules.

4. Forest policies affecting biomass development

Under the Ceauşescu regime, forced industrialization led to substantial imports of technology and increased exports of timber and forest products. With the fall of the regime in 1989 came the appearance of private enterprises in forestry and wood processing and the passage of a law determining the annual allowable cut to be harvested and processed. In addition, the Land Law of 1991 mandated that the Government should return to former owners up to one hectare of forest per recipient. As of 1995, a total of 380,000 hectares had been returned, or 6 per cent of total forest area. It appears, however, that private forest owners are cutting unselectively for immediate profits and not replanting [12].

Forest policy in Romania is set by the Department of Forests within the Ministry of Waters, Forests and Environmental Protection. In addition to setting policy, the Department drafts legislation, regulations, technical guidelines and strategies for forest development, and conducts enforcement through its field units. In cooperation with ROMSILVA, the Department developed a forest strategy approved by the Government in 1993 as part of activities relating to a potential World Bank loan. The report stressed that the degree of privatization of forest lands should remain unchanged (that is, mostly centrally managed). Because 60 per cent of forests are in mountainous regions, central management of the forests was deemed important in avoiding environmental damage in zones of steep slopes [13].

B. Residues of the wood-processing industry

Residues from the Romanian wood-processing industries are a significant biomass resource. According to the National Wood Institute (INL) of Romania [14], the main uses of wood resources are for producing saw timber, veneer, cellulose for the pulp and paper industry, plywood, particle board, fibreboard and furniture. Residues from the processing of these products may include sawdust, wood chips and shavings, large and small chunks of sawn lumber, chemically treated wood residues, as well as bark.*

1. Current availability of wood-industry residues

INL has conducted analyses residues of wood products and their uses. It estimates that in 1995, 230,000 m^3 of wood residues from either forestry or wood industry operations will be available for the production of charcoal for fuel, and significantly more (5.14 million m^3) for firewood to fuel stoves for heating and cooking. With respect to wood-industry process wastes, INL estimates that 1,330,000 m^3 of wood wastes come from primary processing and 490,000 m^3 from secondary processing [14].

2. Current use of wood-industry residues

The greatest biomass energy production in Romania comes from the use of forestry residues (quantified above) and smaller amounts of residues from the wood-processing industry (for which specific estimates are not available) for firewood or charcoal production. These resources are fed into small stoves for heating and food preparation.

Information on the use of wood-processing residues in on-site industrial applications is more accessible. Of total wood industry residues generated in 1995, about 990,000 m^3 are used as raw material in the wood products and pulp and paper industries, while 830,000 m^3 are used for on-site thermal energy generation representing 100 per cent utilization of this biomass resource [14]. On the basis of those figures, an estimated 12,035 petajoules of wood waste was used in wood-industry on-site boilers in 1995, or approximately 8,425 petajoules of delivered thermal energy, assuming conversion in the typical wood-industry stoker boiler operating at 70 per cent efficiency.

Wood wastes provide about 20 per cent of the thermal energy needs of the wood-processing industry, and is likely to increase its contribution. INL estimates that boilers for all thermal applications in the wood industry number close to 550, ranging from 0.1 to 5 MW thermal [14]. According to another estimate by the Romanian Institute for Power Equipment (ICPET), 67 hot-water or steam boilers are using wood or agricultural residues or liquid by-products (black liquor) from the paper industry, for an estimated installed capacity of over 350 MW, although the actual energy generated was not estimated [15]. No data on waste use in the paper industry is available, although it is known that the industry sells bark rather than using large quantities in its own boilers [16].

3. Potential enhancement of wood industry residues

Further enhancement of wood industry residues for energy depends largely on the health of the wood industry itself. Several factors are affecting the ability of the wood industry to thrive. Primarily, the reduced wood harvest over the past few years has limited the operation of Romanian sawmills, and thus production of residues from the wood industry. In 1994 there was a continuation of the downward trend in lumber production, but 1995 harvests were expected to be 35 per cent higher [12].

Limited capital for developing and upgrading the wood industry is another factor inhibiting its growth. In 1994, domestic sawmills operated at 50 per cent of their capacities using equipment of an average age of 20 to 30 years. Investments for upgrading this equipment will have to come from profits,

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*INL is 75 years old and has done extensive work with assessing both the forestry and wood industries. The Institute for Research and Silviculture of Romania also works in this area.

as the Government has refused to pay the costs. Most State mills are seeking joint ventures with foreign companies to obtain the needed investments for upgrading. Problems lie in securing such joint ventures, however, because of the continued involvement of the Government in price controls. Even though sawmills are becoming privatized, the Government controls the price of logs of domestic harvesters at an average of from \$3 to \$5 per m^3, while the European average is from \$40 to \$50 per m^3. Though decontrol of prices is planned over the next several years, mill costs are currently artificially low because the price of the logs purchased for processing is controlled [12]. As these prices reach levels comparable to those prevailing in the rest of Europe, joint ventures may be considered less risky, and therefore more attractive to outside investors.

4. *Wood-industry strategies and policy affecting biomass energy*

Domestic demand for wood products will drive the growth of the wood energy industry, such demand being affected by various key national policies. Foremost in driving domestic demand for wood products is growth in building construction. The return of agricultural and forest lands to previous owners, significant migration from urban to rural areas since 1989, the higher income of rural populations resulting from decontrolled prices for agricultural commodities and from a three-year income-tax break and the relaxation of building-permit requirements have combined to stimulate the construction industry. Even with 1994 legislation that raised construction standards, 1995 estimated demand from the construction industry will continue to grow, as the number of housing starts continues its upward trend. There have been increases of 10 to 35 per cent in housing starts each year since 1993. In rural areas, housing starts have increased by 10 to 15 per cent annually since 1990 [12]. National policies favouring rural construction have thus had the unforeseen impact of facilitating the development of wood-waste resources. The indirect impact of such national policies on the availability of biomass resources, especially in an era of drastically changing policies, cannot be overlooked in estimating the reliability of biomass fuel supplies.

In another vein, as noted previously, high-value uses of wood waste for the lumber and pulp and paper industries attract 54 per cent of the current wood industry residues generated. The future market, therefore, for wood products as well as wood wastes is critical in determining the viability of wood-to-energy project development. For instance, demand for higher-quality wood products is likely to limit the types of wood waste available for energy production. Today Romania produces low-quality particle board and fibreboard using up to 30 per cent of sawdust. Hitherto, from 15 to 20 per cent of sawdust from the timber industry has been used for particle board. Sawdust content, however, must be reduced to raise particle-board quality, meaning that other types of wood wastes may be directed towards the particle-board process. Therefore, the fate of wood waste use is closely tied to the industrial and silvicultural strategies and development approaches [16].

C. Agricultural-crop field residues

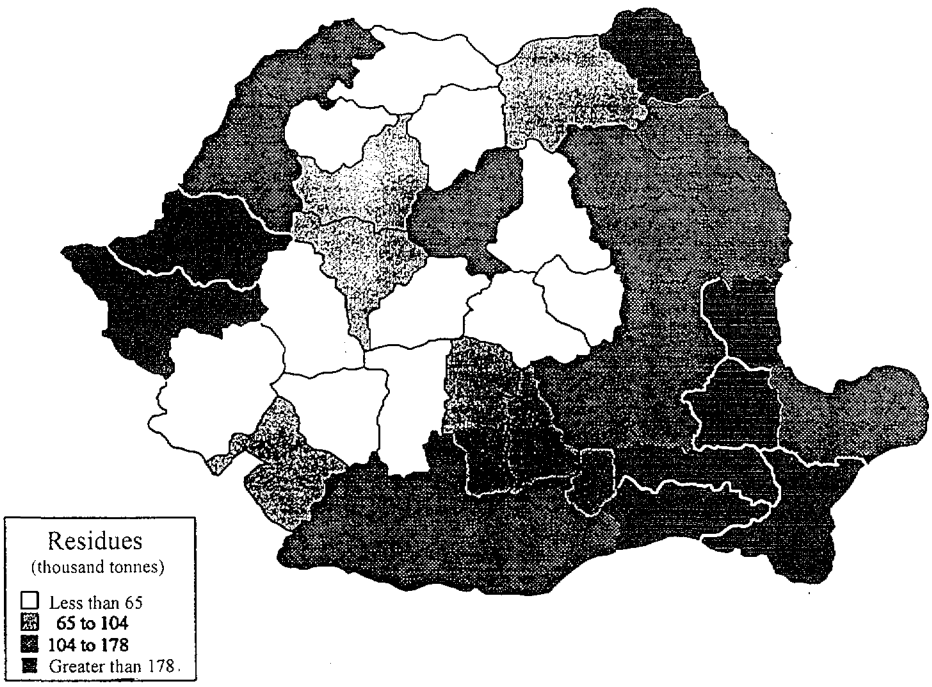
The main agricultural crops in Romania that could offer field residues (those that could be collected from fields during or after harvesting) for energy generation are cereals (wheat, rye, barley, oats and maize), tops of sugar beets, vine shoots from grape vines and trimmings from fruit trees. The main processing industries that operate on a large scale and produce residues potentially valuable as energy feedstocks are sunflower seeds (shells), maize (corn-cobs and alcohol), cotton and flax and, potentially, sugar beets (digestible residues). Because of the lack of consistent and useful data on residue generation and use, estimates of biomass energy potential of processing industries could not be established.

Agricultural residues are difficult to quantify, since the large State-owned farms were dissolved after 1989. In addition to undermining farm productivity and efficiency, such a situation gives rise to severe difficulty in tracking and quantifying the generation and use of agricultural residue in Romania.

1. *Current availability of agricultural crop field residues*

In the present study, estimates of cereal and sugar-beet field residues and of vineyard and orchard prunings available for energy production are based on national crop-yield statistics and areas under cultivation in 1994 [17]. Crop-to-residue ratios and estimated residues per unit area under cultivation are used to estimate levels of residue generation. The year 1994 saw increased cereal production over 1993 yields, and it was estimated that for 1995, production would again increase, approaching levels of production prior to the sharp drop in 1992 [18]. The total tonnage of field residues from cereals and sugar beets available for energy production is 5,816 million tonnes, with an energy content of 101,774 petajoules. Figure XI.3 presents a map depicting the counties with the largest quantities of agricultural crop field residues.

Figure XI.3. Cereal field residues



The smallest Romanian wineries each have at least 500 hectares, while some are much larger [19]. To estimate vineyard clippings available for energy production, the total area of Romanian vineyards and estimated recoverable clippings and associated energy content were used. The same methodology was applied to estimate clippings from fruit trees. Together, the woody residues amount to an estimated 21,063 petajoules of potential fuel for energy production.

2. *Current use of agricultural crop-field residues*

Agricultural crop residues are not widely used for energy production, though efforts are under way to improve collection and management of such residues to make them available for energy conversion. Currently, harvesting of residues is primarily manual. Development of a bundling and briquetting technology, however, appears to be entering the manufacturing phase. The problem of how to feed the biomass bundles into a combustion system and how to induce industry to reinvest in such combustion systems remains unsolved [19, 7]. The technology is likely to remain too expensive for small farmers to invest in for the near term, unless a stable market for biomass residues develops.

Some grapevine branches are used as domestic fuel by winery workers. Some branches stay on the vineyards to mix with the soil, but apparently only to replace the nutrients, not to enhance soil substrate. Many of the big branches (when vines are replaced) are collected by hand and burned in a pile in the field [19].

Some use is being made of biomass residues from agricultural products. Cotton and flax wastes, corn-cobs and alcohol produced in maize processing and sunflower-seed shells are apparently used on site for energy although on a very small scale. Lack of data on the practice, however, prevents an assessment of the current or potential contribution of those sources to energy production. INL nevertheless estimated the actual use of agricultural wastes in Romania in 1994 to be 850 terajoules, primarily for small cooking and heating applications [20].

3. *Potential enhancement of agricultural-crop field residues*

The Romanian Institute for Scientific and Engineering Technology Research for Agricultural Equipment has developed a technology for making compact subbriquettes from corn husks and grapevine branches, and it is hoped that it will also be able to do the same with forestry residues and other vegetable crop residues. Since the briquettes are not compact, the biomass dries naturally. The technology is already being applied in a form that can be attached directly to a tractor, although additional analyses must be completed to ensure that the technology will use less energy than it can provide in the form of briquettes. Finding uses for the briquettes presents another problem. The initial investment in combustion steam systems that could handle solid biomass residues is usually too great for wineries and farms. Most wineries currently use liquid fossil fuels, and would have to invest in modified fuel-handling and combustion systems to use solid fuel [16].

4. *Agricultural policies affecting biomass development*

The Land Law of 1991 mandated the distribution of land belonging to the agricultural cooperative farms, thus re-establishing the ownership rights of previous land owners. Land reform has created some structural problems in Romanian agriculture. Some 14 million hectares of agricultural land have been divided into 40 million lots and returned to private ownership. Because lot sizes can be as small as one half a hectare, and since a single owner's holdings are typically made up of non-contiguous lots, consolidation of holdings into parcels large enough to promote efficient farm production has been difficult. Many owners have grouped their lots together in associations in order to farm on a larger scale [21]. According to officials of the Institute of Studies and Design for Agriculture and Food Industry Construction, 80 per cent of farms are privately held by 6 million owners. Only about 25 per cent of farms are considered large, and most of these are still State-owned.

D. Energy crops

Energy crops in Romania are considered to be only a long-term biomass-energy-resource option because the production and conversion of energy crops are not proven technologies. Research has been conducted on the production of energy crops in Romania to a limited degree. One particular research effort looked into the use of high-sugar-content sorghum for fermentation to produce ethanol, which would in turn be transformed into a fuel, such as gas for cooking and running agricultural machinery. The study looked only at using the fuel in existing machinery that could not accommodate pure ethanol. Calculations showed that the process could be competitive if about 17,000 tonnes of fuel per year were produced. The Ministry of Agriculture (the benefactor of the study) wants to conduct two pilot projects to collect data. Because of the current lack of financial resources for R and D, however, it is uncertain when they might be implemented [22].

1. Current availability of energy crops

Romania does not produce crops specifically for energy feedstocks, except possibly in isolated research cases for which specific data are not available.

2. Current use of energy crops

There are no current uses of energy crops in Romania other than for research purposes.

3. Potential enhancement of energy-crop resources

Energy crops production is not based on a proven technology. Given the level of technological experience, the availability of investment funds and the strong bias even against proven biomass energy technologies in Romania, energy crops are considered to be only a long-term option.

Land availability for growing energy crops, however, looks promising: in a 1991 analysis of six eastern European States [9],* Romania ranked second only to Poland in potential land available for energy crops. To estimate potential future opportunities for energy crop development in Romania, the land suitable for energy crops was considered to be 5 per cent of all forest lands, pasture-land and arable agricultural land in Romania. This land area of 902,830 hectares could yield 9 million tonnes of short-rotation woody crops by the year 2020, and represents an energy potential of 180,566 petajoules per year.**

Short-rotation woody crops are the most feasible energy crop option for Romania in the long term, on the basis of technical, policy and institutional factors. Herbaceous energy crops do have some advantages, such as: ease of harvesting using conventional agricultural equipment; increased soil stability over traditional agricultural crops, as land is not tilled each year and grasses regenerate naturally; and no introduction of woody roots into agricultural land, thus facilitating conversion of the land back to food production in the future. Other factors, however, weigh against herbaceous energy crops being feasible in Romania within even the midterm, including the following:

(a) Energy conversion of herbaceous energy crops continues to pose significant technical barriers, such as serious slagging in boilers;

(b) The current structure of the agriculture sector in Romania makes reliability of the supply of herbaceous energy crops questionable. Herbaceous energy crops are most likely to be cultivated on existing agricultural land or pasture-land, currently divided up among 6 million owners and managed through a constantly changing set of associations and cooperatives. The next few years will see even more shifts in ownership and cultivation as the fate of land tenure and the development of a land market unfolds. A market for energy crops could not be established without a reliable fuel supply, which is only possible in the long term.

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*Bulgaria, the former Czechoslovakia, Hungary, Poland, Romania and the former Yugoslavia.

**This assumes a yield of 10 dry tonnes per hectare per year and 20 gigajoules per dry tonne of woody energy crops.

On the other hand, nearly 95 per cent of all forest lands are managed centrally by the State. It is not anticipated that forest land would be cleared to grow energy crops, but rather that other lands, such as degraded lands, lands available for afforestation, and unforested lands held by the State forestry company, ROMSILVA, would be appropriate for energy crops. These lands could readily be identified and cultivated by experienced staff and departments that have long-term security and forest management plans to lend reliability to the future stream of woody crops for energy. In addition, recent studies completed in conjunction with the World Bank have indicated that Romanian forests should remain under State ownership and management, particularly because of the fragility of much of the forested lands on steep slopes. In turn, private agricultural landholders could still engage in woody energy crop production, with guidance, long-term planning and management coordinated by government foresters. Energy crop management could also be run in coordination with afforestation programmes in planting and establishing new forested areas and new short-rotation woody energy crop lands.

Another benefit of woody energy crops is the potential to use them as stabilizers on highly eroding land and steep slopes. Because harvesting would be less frequent than with herbaceous energy crops, potential land disturbances would be reduced. Figure XI.4 illustrates areas of high-energy crop potential based on land that overlaps with highly eroding lands.

E. Livestock wastes

The Government of Romania, through its multiple research institutes, has conducted extensive research into the production of biogas from anaerobic digestion of livestock wastes and sludge from waste- water treatment facilities. Today, many of the research programmes, as well as the majority of biogas production facilities, have been abandoned or dismantled because of a lack of resources, as well as a redirected focus on natural gas for supplying gaseous fuel needs. Also, livestock populations began to drop in 1989, and have continued to plummet as a result of economic hardship; manure production has therefore gone down as well [17].

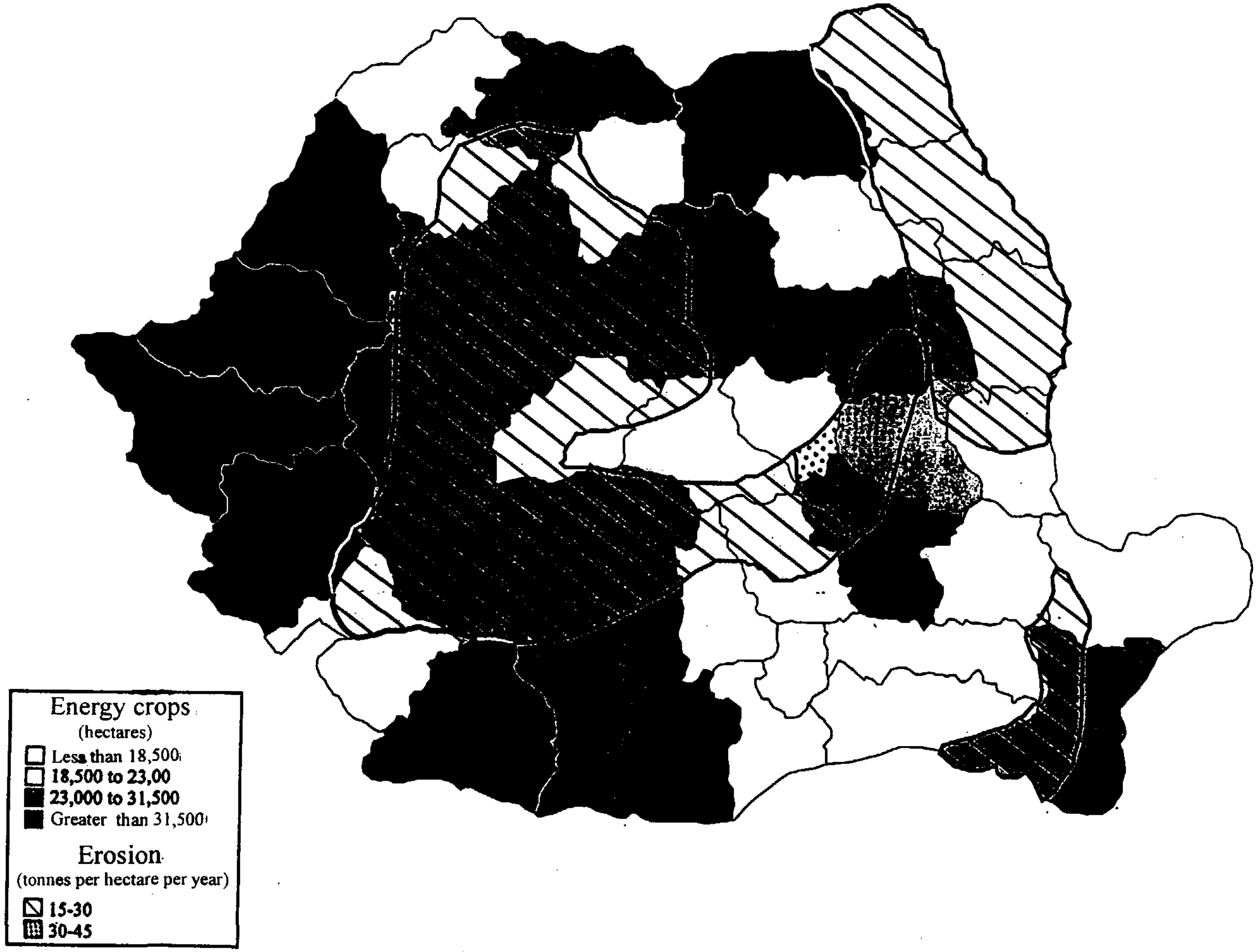
1. Current availability of livestock wastes

Since the dissolution of the majority of large State farms and the privatization of much of the livestock industry, data on manure has become unavailable. Prior to 1989, the centralization of those farms and government research into methane generation allowed for regular tracking of data. For that reason, in the present report it has been possible only to estimate manure production using data on livestock populations and accepted conversion factors. Current production of livestock wastes was estimated by multiplying the number of head of animals [17] by worldwide species-specific dung production factors [23].

Under current livestock management practices, it is assumed that only one eighth of livestock wastes is recoverable. This estimate is consistent with recent analyses [24], and also accounts for the livestock management practices in Romania. For instance, fragmented land ownership has caused dispersed animal ownership and smaller herd sizes. In the dairy industry, many farms are likely to have fewer than 10 cows. Animal housing is also in transition. While some livestock are still housed at privately-owned collective farms, most are kept in small stables near homes or in rented facilities where poor waste management is the norm. In addition, information on feeding practices (confined versus grazing) are unavailable, and therefore make manure collection from confined feeding facilities (which are the most suitable for anaerobic digestion facilities) difficult to estimate [25].

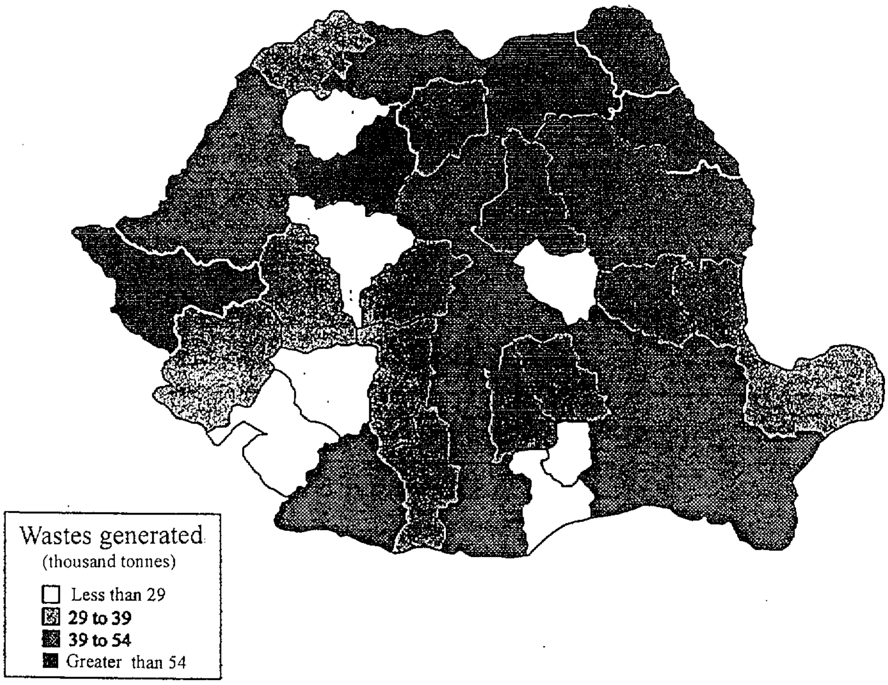
The total quantity of livestock waste estimated to be available for energy production at the end of 1994 was 1,037 million tonnes, which if anaerobically digested could yield 281 million m^3 of biogas, or 6,305 petajoules of potential energy. INL has estimated that available resources (anaerobically digested

Figure XI.4. Correlation of energy crop land availability and agricultural land erosion



to produce biogas) represented a potential 6,018 petajoules in 1995. The map in figure XI.5 shows the distribution of potentially recoverable livestock wastes in Romania.

Figure XI.5. Animal waste



2. Current use of livestock wastes

Current estimates are scarce, and the Government has been unable to keep track of biogas facilities still in operation on privatized farms. Nevertheless, a few of the biogas facilities are still operating. INL has estimated that actual biogas production and use on farms in 1994 was 240 terajoules.

3. Potential enhancement of livestock wastes for biogas production

There still are some large State farms, about 25 per cent of the total, for both livestock and crop production. There are also some large private farms (40-50 companies) that have, for example, 15,000 head of pigs, 200-400 dairy cattle, or 2,000-3,000 beef cattle. Nevertheless, there is a lack of funds to rehabilitate biogas installations even at those facilities. Perhaps more daunting than the lack of funding is the pervasive bias against biogas production and use, based on past experiences. As a result, near-term development of this abundant resource is improbable [16]. Privatization of pork production may represent increased potential by providing substantial confined feeding facilities.

F. Urban waste

Typical Romanian urban waste characteristics are as follows:

(a) Over 60 per cent decaying organic matter;

(b) Over 50 per cent moisture content;

(c) Low proportion of materials with high caloric value such as paper, cardboard, wood and plastic;

(d) Low caloric efficiency, ranging from 500 to 700 kilocalories per kg [26].

Because of those characteristics, landfills have been found preferable to combustion, which could require a significant addition of fuel or thermal energy. Both this fact and the relatively high capital costs of incineration facilities has led Romanian researchers to advocate the outfitting of landfills with proper environmental controls, including methane gas collection systems [26]. After 1989, there was significant international pressure to jointly develop waste incineration plants in Romania. At least in one case, however, this would have involved importing hazardous wastes from another country to incinerate in the facility, and an agreement was therefore not reached [27].

Recycling in Romania is currently organized at the national level and carried out by an association of 44 companies (called REMAT) with majority State ownership and one company located in each county capital. The REMAT companies are in the process of privatization, and there are also 200 privately owned companies. The recycling activities focus on commercial and industrial non-organic materials such as glass, rubber, and scrap iron, but at least one organic combustible resource, scrap paper, is also the focus of recycling activity. The main partners in managing recovered materials are recyclable materials generators and consumers of recyclable materials such as paper-mills and non-ferrous metallurgy and rubber industries. The environment law currently being debated in the Parliament of Romania contains additional provisions regarding recycling, although the likely impact of the law on the waste stream is unknown [28].

In 1995, the National Recycling Commission began an analysis of how to manage and reuse urban household waste, considering incineration, gasification and pyrolysis. It also considered the possibility of introducing sorting units for reusable materials, organic materials and building waste. According to Commission officials, in-home sorting may be the most feasible approach, given the current structural and budget limitations of local administrations. Local administrations in some other countries of eastern Europe have implemented selective collection of household waste directly from the population, whereas in Romania, household wastes are recovered only through specific REMAT collection points. Those collection points have decreased from 2,000 in 1989 to 700 in 1995 as a result of significant local taxes placed on REMAT, leading to the destruction of the majority of recoverable resources [29].

1. Current availability of urban solid waste

Over 54 per cent of the population of Romania was living in urban areas (12.4 million people) in 1994. Production of domestic refuse is estimated to be 0.5-0.9 kg per inhabitant per day, amounting to a potential 3,168 million tonnes per year in urban areas [26]. The amount of methane gas that a modern sanitary landfill could generate is approximately 9.5 million m^3 per year. If Romania disposed of this quantity of waste each year in sanitary landfills, a potential 1.7 terajoules of biogas could be produced each year after 10 years of disposal.

2. Current use of urban solid waste

Ninety per cent of domestic refuse is disposed of through simple dumping without any environmental controls, while 10 per cent is directed towards controlled dumping and incineration. Only two sites in 1994 were classified as sanitary landfills, and incineration was found to occur at only seven small-scale experimental plants, each with a capacity not exceeding 75 tonnes per day [26]. One urban waste incineration facility was initiated in March 1994 through a joint venture between two French firms for a 30-year contract. The price for waste disposal will be $14 per tonne, resulting in a monthly tax on local citizens of three towns of 600 lei ($0.30)* per person. Opening the first of 12 combustion cells will require an investment of $1.5 million, the first and largest investment of this kind in Romania. The firms have obtained investor certificates from the Romanian Development Agency. Thermal energy from the waste incineration is planned for use in greenhouses and solariums [30]. To date, recycling efforts have been successful in recovering industrial wastes (about 32 per cent of waste paper is recovered and used in paper production), but not domestic wastes. The likelihood is low that Romania will successfully implement a domestic waste-recycling programme in the near term. Such a programme would have a would significant impact on the composition of the urban domestic waste stream [26].

3. Potential enhancement of urban waste resources

Though legislation is under consideration that may affect waste management, current laws and regulations do not provide an adequate legal framework for developing the waste management and control sector. A consistent waste management policy or strategy that covers the whole field of waste management issues does not exist, even though many of these issues are already specifically mentioned in existing laws and regulations. Finally, the magnitude of taxes, fines and penalties related to waste management are insignificant, and therefore ineffective [26].

The Romanian Research and Engineering Institute for the Environment has scaled up a sanitary landfill technology using geomembranes and gas collection systems from a pilot-scale model (5 m^3) to an industrial unit (50,000 m^3). The system operates using anaerobic composting (dry anaerobic fermentation). The pilot-scale model produced 390 m^3 of gas (60 per cent methane) per tonne of volatile solids at 55° C, using a retention time of 15-20 days and a total solids content of 30-40 per cent. With the same conditions and only 25 per cent solids, gas production was 392 m^3 per tonne of volatile solids. The industrial demonstration facility, the first in Romania to use controlled landfills of domestic waste with high-density polyethylene geomembrane, is located at Sibiu, and was installed in June 1994 [26].

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*Using a conversion rate of 2,000 lei per United States dollar.

XII. PROMISING OPPORTUNITIES FOR BIOMASS USE AND POTENTIAL

Chapter XI focused primarily on biomass resources, their current potential and factors affecting the resources themselves. The present chapter examines conversion technologies and niche applications for biomass energy, and estimates some potential economic and environmental benefits from pursuing those paths.

A. Current biomass energy conversion in Romania

ICPET has either designed or studied over 80 per cent of the power equipment produced in Romania. Most industrial solid-fuel boiler technologies used in Romania have also been designed by ICPET and manufactured domestically, with the exception of a few boilers imported specifically for the wood and paper industry. Research on fluidized bed boilers, begun over 20 years ago, resulted in the rehabilitation of some industrial boilers and the construction of 50 stationary fluidized bed boilers for steam or hot water, 20 of which are still in operation. The most commonly used industrial boiler technology is the fixed bed boiler. Table XII.1 lists the types, ranges and numbers of industrial steam and hot-water boiler technologies operating in 1995 [15]. RENEL solid-fuel (hard coal and lignite) plants almost exclusively use pulverized coal boilers and no cyclone boilers [31].

Table XII.1. Hot-water and steam boilers operating in Romania

Boiler Type	Capacity (MW thermal)	Number of units
Fixed bed	<1	150
Moving grate	<2	25
	2-5	30
	5-10	18
	>10	8
Stationary fluidized bed	2-5	10
	5-10	8
	>10	2
Special boiler	2-5	15
(wood or agricultural wastes, liquid by-	5-10	40
products from paper industry)	>10	12

Source: Institute for Power Equipment (ICPET S.A.), memorandum to DynCorp (Bucharest, October 1995).

The main concerns with existing boiler technologies fired with fossil fuels are emissions of particulates and sulphur dioxide and low combustion efficiencies. In using biomass, the mechanical feeding of agricultural and wood wastes has posed problems as well. Currently, the national institutes hope to continue technological improvements, but are limited by a lack of funding [15].

Boilers used specifically in the wood-processing industry, of which there are about 10 different types, tend to be primarily stoker boilers, although 10 fluidized bed boilers are operating in the industry. Steam boilers in the wood industry are generally characterized by maximum efficiencies of 70 per cent and steam production ranging from 1 to 7 tonnes per hour. Three boilers, the HLK 7/14, IPROM 7/14 and BW, can deliver up to 14 tonnes per hour by cofiring biomass wastes with fossil fuels. In general, the wood-waste handling and combustion systems are designed to burn wood waste (primarily sawdust and wood chips) at the same rate at which they are produced, and for this reason industrial facilities typically have no storage warehouses for wood wastes other than bins. Wood fuels gained acceptance after the fossil fuel price shocks of the 1970s, during which time new wood-waste boilers with higher technical and economic performance were designed. One steam boiler for small applications that accepts solid fuels was quoted in October 1995 as costing 10 million lei ($5,000) [32].

Three wood-waste-fired co-generation systems have been constructed in Romania, but none of them is currently operating. Two 200-kW installations were constructed prior to 1989, followed more recently by a 450 kW installation. The latter is suffering from the absence of steam customers, and was apparently flawed as a result of inadequate feasibility studies in the rush towards privatization [14]. Other biomass co-generation research efforts have focused on cofiring with liquid or gaseous fuels, rather than with solid fuels. Despite flaws in existing facilities, biomass co-generation shows potential. Analyses by the Energy Research and Modernizing Institute have showed that three different systems coupling a biomass gasifier with an engine or turbine lead to a 12 per cent reduction in the price of electricity when used in a combined heat and power plant rather than in a simple electric generating facility [32].

A 1993 Environmental Order (number 462) establishes strict air emissions requirements for new installations, and requires retrofits of existing installations over a period of seven years, including the retrofit and upgrading of many of the current wood combustion systems. Some of the old boilers have adequate efficiencies, but their stepped grate systems could be changed to reduce emissions. Alternatively, a fluidized bed boiler with a stoker could be installed at facilities with low-to-medium marginal costs to improve emissions rates and efficiency. There are currently only about 10 fluidized-bed installations in the wood industry, but proposals have been made to upgrade other facilities by installing the technology. Of the 550 wood-waste boilers, about 300 will need to change the grate system to meet the new environmental regulations, representing a potentially significant market for the advanced technologies [16].

B. Emerging markets and applicable biomass technologies

Biomass energy resources need to be approached using both a near-term and long-term perspective for several reasons. Seizing near-term opportunities for biomass energy provides immediate demonstrations of system performance necessary to minimize skepticism about technological and economic viability. Building on in-country biomass experience for immediate application of existing biomass technologies should also include stepping up to technologies with higher efficiencies than those currently used in Romania. The long-term perspective is also critical because biomass, having a lower energy content per unit mass than its fossil fuel competitors (except lignite), must achieve high efficiencies or maintain very low delivered fuel cost to remain competitive. Emerging advanced technologies offer these high efficiencies. The long-term perspective is important also because the availability of future biomass resources depends heavily on long-term sustainable forest and agricultural management that can be affected by any number of policy changes. Biomass energy developers must therefore plan for the shifting political and economic trends that could have a potential impact on biomass fuel supply and alternative supply options.

1. *Near-term opportunities*

For near-term success with cost-effective, high-performance biomass energy applications, project development should focus on low-cost feedstocks combined with systems that allow for relatively short start-up periods. Such a strategy is critical to readily proving the viability of this energy resource, rather than risking continued skepticism through additional study and trials of experimental technologies. Accordingly, the recommendations for near-term biomass energy development contained in the present report focus on exploiting abundant solid biomass waste resources that can be used in existing systems with very little fuel preparation. In most cases, this will mean the use of wood wastes.

Stand-alone electricity generation does not offer great near-term market opportunities for biomass energy resources for several reasons, in particular the following: Romania enjoys nearly 100 per cent access to electricity (only the Danube delta and the mountainous regions have some remaining unelectrified areas that use diesel generators); hydropower resources are able to mitigate the impact of the relatively unreliable and inefficient fossil-fuel power plants; 1990 electricity demand will not be exceeded until 2003-2005; and electricity prices, though expected to rise in the coming years, remain relatively low [1]. Therefore, near-term recommendations include electricity production when it can be coupled with thermal energy production and when multiple other benefits may accrue as well. Some of the best options for biomass applications are outlined below:

Coupling the use of high-efficiency technologies (such as co-generation) with on-site or local wood wastes by successful and growing industries that have process heat requirements

Though electricity generation offers only a marginal market for most biomass energy producers, certain industries nevertheless may be able to incorporate co-generation systems that offer greater benefits than costs. Equipment upgrades that will occur throughout the economy as investment funds become available offer opportunities to introduce high-efficiency biomass energy technologies that provide multiple benefits to industry. Targeting successful and growing industries is particularly important when considering upgrading to accommodate on-site industrial co-generation systems. The generation of electricity adds system complexity and requires additional staff, an entrepreneurial spirit and investments that only strong and expanding companies with access to private capital will be able and willing to make in the economic climate of Romania. Even in countries where biomass co-generation is an established technology, such as the United States, lumber mills and wood-products manufacturers often find the addition of electricity generation taxing because it requires considerable technical, financial, legal and commercial knowledge in new areas. As Romania enters into the age of private power generation and sales, identifying industrial co-generation projects with the highest potential success rate will be extremely important if the types of problems faced in other countries when attempting to maximize energy efficiency through co-generation are to be avoided.

The furniture industry may represent one of the most promising target industries. The construction boom is raising demand in the furniture industry, which has remained strong throughout the economic transition and downturns experienced by most other industries. Although 1994 sales of furniture were low because of the abolition of credit sales, the industry was able to upgrade some of its equipment and improve efficiency with new foreign investment. The furniture industry of Romania accounts for 50 per cent of all exported wood products, and a 60 per cent increase in furniture exports is anticipated over the next five years [12]. With this positive projection, the furniture industry may represent one of the best targets for increased and improved use of wood wastes for energy production. Targeting specific industries can help biomass energy build a solid reputation that can readily be replicated, and will help biomass energy developers focus their efforts on tailoring biomass energy systems for maximum performance as they come to better understand the users of these technologies [17].

Industries generating biomass wastes face serious financial and technical obstacles. Upgrading to biomass-fired on-site co-generation in some cases may require investments equal to or greater than that made in the primary businesses. It will therefore be important for Romanian industry to seek partners that offer the experience and technical skills to develop energy projects. The most viable projects will involve a power project developer as a partner. Under such an arrangement, the partner bears most of the burden of financing the power system, staffing the power plant and negotiating energy contracts and prices with the utility and other potential energy customers. In return, the industry is able to manage its biomass wastes, reap either savings or cash income from these biomass resources, and perhaps even become energy self-sufficient.

Capitalizing on RENEL experience and coal-fired power infrastructure to demonstrate appropriate biomass cofiring applications

Romania offers a key opportunity to maximize the efficient use of biomass energy by capitalizing on its extensive experience with coal-fired systems. While all RENEL coal-fired power plants are equipped with simple condensing turbines, RENEL uses lignite, as well as oil and gas, to fire both condensing power plants and co-generation plants [1]. Of the lignite-fired plants, nearly 20 per cent (1,438 MW) of installed capacity is in combined heat and power plants. RENEL hard-coal and lignite plants (representing 35-40 per cent of its generation capacity) use pulverized coal boilers almost exclusively, although they also operate approximately 20 atmospheric, stationary fluidized-bed coal boilers (nearly 30 additional boilers of this type were operating in the past) [31].

While neither the pulverized coal nor the stationary fluidized-bed boiler technologies is optimal for accepting large quantities of biomass fuel (as are simpler stoker boilers and cyclone boilers), pulverized coal boilers using hard coal or lignite could accept up to 5 per cent wood by mass into the fuel mix with no modifications to the existing system. The wood could be copulverized and fired with coal in an existing pulverized coal boiler. With modifications to fuel handling and burners, an existing pulverized coal boiler using hard coal can accept 10 to 15 per cent wood by heat input (20-30 per cent wood by mass), but this may not be cost-effective [33].* For coal-fired power plants in the range of 150-200 MW using 10-15 per cent wood by heat input, wood-fuel feed rates would be 8.5-11.4 oven dry tonnes per hour [34].** The Oltenia basin of Romania, along the forested southern Carpathian foothills, has the greatest deposit of lignite and several lignite-fired power plants that could offer opportunities for biomass cofiring [4]. By targeting RENEL to cofire with biomass in its hard-coal and lignite plants, a stable market for biomass fuels could be established, and critical experience in biomass combustion can be gained at the national level where energy policy is determined. These applications may also provide excellent opportunities to develop and expand the use of solid biomass fuels other than wood-industry residues and forestry wastes, such as vineyard clippings, corn-cobs, and sunflower-seed shells, depending on site-specific matches between resources and appropriate available technologies.

Cofiring biomass fuels with fossil fuels has been considered by Romanian researchers, but only with liquid or gaseous biomass and fossil fuels. Recently, however, requests have increased for boiler technologies that can cofire solid biomass fuels, particularly wood or agricultural wastes, with lignite. Romanian technical experience in this area is minimal, and technical training and technology transfer activities would be important to support and expand the application of cofiring. Currently ICPET is

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*Cofiring wood at the level of 20-30 per cent wood by mass with coal requires wood to be received, prepared and stored separately, pulverized to less than 0.6 centimetres in size, dried to at least 20-25 per cent moisture, and fired through separate burners, though an existing boiler can be used. See Tillman and others [33].

**Fluidized-bed boilers can also accept wood into the fuel mix, but reductions in sulphur dioxide emissions may not be achieved, and efficiency may be reduced somewhat.

conducting its first test on the combustion of wood wastes in a 1-MW circulating fluidized-bed combustion plant, and intends to conduct biomass cofiring tests with lignite [15].

Niche applications for biomass-fired or cofired district heating systems

In Romania, thermal energy production offers a significantly better market for biomass resources than stand-alone electricity production. Like expected electricity demand, thermal energy demand is not expected to reach 1990 levels until after 2005. Thermal energy supply, however, is now often insufficient during the colder months [1, 7]. With population growth in rural and smaller urban areas steadily rising and the Government supporting this migration pattern, biomass-fired thermal energy for district heating in rural towns and small cities should gain some degree of support. Local and national governments that support rural migration have a logical reason to support services such as locally fuelled thermal energy supplies to help ensure an adequate standard of living in smaller, dispersed communities. Romania has a long history of and firm commitment to district heating. Integrating biomass fuels into the district-heating resource mix can provide a high-visibility proving ground using a simple yet valuable technological application.

Assuming an available biomass energy supply, district heating systems represent perhaps the most immediate and low-cost biomass application in Romania. They also offer wide exposure to a reliable, simple biomass energy application, thus helping to improve the reputation of biomass energy. Nevertheless, it is recommended that higher priority be given to combined heat and power plants, industrial co-generation and cofiring in coal plants, in order to emphasize the most efficient use of indigenous renewable resources from the beginning of renewed efforts to promote and expand biomass energy applications.

2. Mid-term and long-term opportunities

One particularly significant opportunity to enhance the use of biomass energy in Romania is to target the wood and charcoal burned in small stoves for cooking and heating. Nearly six times as much wood is used currently in these applications (4.5 million m^3) as in industrial wood boilers (830,000 m^3). Improving the efficiency of this large demand is important not only to the users, but to the potential future use of biomass in Romania. While upgrading small-scale stoves would appear to be a near-term opportunity, given the situation in Romania it is more likely to be a mid-term opportunity. Upgrading numerous, small-scale cooking stoves on a significant scale requires integration with other rural development and extension activities. It also depends largely on the ability of the population to purchase such systems, or the development of a social programme to subsidize system costs. The near-term variability of rural incomes, the fact that economic reforms plan to eliminate subsidies for rural energy supply and the tendency to supply more centralized energy through district heating and gas supply all combine to make upgrades of wood stoves a mid-term opportunity. As wood-stove efficiencies improve and as wood stoves are replaced with other energy systems such as natural gas, the use of biomass in residential cooking and heating is likely to decrease.

Attention should also be focused on repairing the damage done to the reputation of biomass energy from experiences under the communist regime. This requires, however, at least a mid-term perspective to turn around public perceptions and preferences. In particular, biogas production from the anaerobic digestion of livestock wastes, sewage sludge at waste-water treatment plants and the collection of landfill gas could provide valuable resources and simultaneous environmental benefits over the longer term. Biogas production and collection technologies are relatively simple and inexpensive in their most basic designs, though they do face significant technological barriers in colder climates. The benefits, however, reach far beyond energy recovery, including reductions of greenhouse-gas emissions, improved waste management and environmental control of pathogens. The most likely approach to bringing about the widespread adoption of biogas recovery is by promoting its environmental benefits in combination with its energy recovery value.

Rehabilitation and installation of modern biogas facilities would be deemed a near-term opportunity were it not for the serious public resistance to these technologies and the real technical limitations of sustaining operations in colder seasons when energy demand is greatest. Landfill gas collection systems are considered to be proven state-of-the-art technologies for sanitary landfill design today around the world and do not face as great a technical barrier in cold climates. In many cases, landfill gas may still be flared rather than recovered and used to produce energy, but the gas collection system can just as easily be used to supply an energy production system. Capitalizing on cost-effective projects that prove the reliability of landfill gas collection and use in the near-term could result in shifting attitudes away from the disillusionment with on-farm biogas projects of the past. An important aspect of shifting current biases is to incorporate education and information transfer to policy makers and local decision makers who decide how urban wastes will be managed. Decision makers in municipalities and rural agricultural communities and industries need to be educated about the emerging success of biogas technologies, whereas education regarding cofiring and co-generation at industrial and public facilities might better be targeted at business leaders, investors and regional and national decision makers.

Other long-term opportunities include the development of energy crops (discussed in chapter XI, section D of this study), as well as the application of more advanced conversion technologies that will reduce the delivered energy costs of biomass energy.

C. Economic and environmental benefits from biomass utilization

The utilization of biomass energy resources in Romania offers significant potential economic and environmental benefits. The following two sections provide an overview of some of the benefits associated with the proposed near-term, mid-term and long-term opportunities.

1. Economic benefits

The potential economic benefits of biomass development must be evaluated against a backdrop of constantly changing economic conditions. In the 1990s, Romania is seeing substantial reductions in national output, increasing unemployment and a slow transition from State ownership to private industry. The economy bottomed out in 1992 after experiencing a 46 per cent drop in production over three years. Current growth in the gross domestic product (GDP) is between 3 and 4 per cent, but unemployment remains problematic, and the planned transition to a private-enterprise, market-driven economy remains very slow [35].

In such an economic climate, it is difficult to estimate potential economic benefits to individual firms and the country from implementing near-term industrial biomass energy opportunities. Through the first half of 1995, Romania had privatized only about 1,000 of 6,500 State-owned firms, and more than 800 of those were small firms. Of those firms targeted by the Government of Romania for privatization, the top 30 per cent are energy-intensive [36]. Thus privatization and market reforms can be expected to lead to large reductions in energy consumption, resulting in downward pressure on demand and domestic energy prices.

Nevertheless, a number of areas are economically promising for biomass energy development. For example, Romania offers an emerging market for potential investors interested in joint ventures with wood-based industries or potential heat and power producers. The Electricity and Heat Law of Romania (see chapter XIII, section B) is opening up the private power market, and the upward trend in energy prices and removal of subsidies will make the energy market more attractive in the near future. Although its slow rate of economic transition has limited foreign investment activities in Romania, recent economic trends and reforms are now making it a more hospitable investment environment.

Industrial biomass energy development holds potential cost savings for industry. On-site thermal energy or electricity production using local or on-site biomass could substantially reduce industrial energy costs. With co-generation systems, firms may actually generate additional revenues from the sale of self-generated electricity.* As privatization expands, firms will probably place increased emphasis on efficiency, since the reduction of energy subsidies will help provide the necessary price incentives to encourage efficient on-site biomass waste use. Higher energy prices will also encourage industry to explore self-generation of electricity as a cost-cutting strategy, with the possibility of surplus electricity and heat sales to provide an additional revenue source.

Among Romanian industries, wood processors are the most likely candidates for achieving economic benefits from biomass energy use. The 250 wood-industry boilers that are facing serious problems relating to non-compliance with new environmental regulations and the additional 300 wood boilers that will require less significant upgrades in the medium term represent a tremendous unmet demand for facility investments. By focusing on upgrading to high-efficiency systems either through installation of more efficient boiler technology or co-generation systems, wood-processing industries may be able to attract outside investors, especially those interested in private power production who are seeking partners to provide a biomass fuel supply.

Economic benefits may also be realized through biomass use in existing public thermal energy and electricity generation facilities. The current electricity-generating infrastructure of Romania could accommodate cofiring 5 per cent woody residues (by mass) in pulverized coal power plants with no system modifications. At current capacity utilization rates (about 32 per cent), biomass has the potential to displace roughly 1.4 million tonnes of lignite in Romanian power plants by burning an approximately equivalent amount of wood wastes in its place, depending on the moisture content of each fuel.** At a cost of $19 per tonne of lignite [1], this quantity of lignite would be valued at about $26 million. The World Bank has recommended converting from lignite to imported hard coal in 11 units totalling 550 MW of installed capacity. In this case, cofiring with biomass would displace hard-coal imports as the facilities shift away from lignite [1]. Similar benefits might also be realized in Romanian district heating systems. A lack of detailed data on fuel use and biomass compatibility of these facilities, however, prohibits a quantitative estimate of benefits.

Mid-term opportunities to upgrade residential wood-fired cook stoves allows for the more efficient allocation of indigenous biomass resources. Cook stoves and small furnaces currently in use in Romania are estimated to have combustion efficiencies of about 15 per cent. If residential use of wood decreases as a result of increased efficiency and replacement with gas supply, then wood is freed for use in industrial, electric-utility or district-heating boilers that may achieve efficiencies of up to 70 per cent. The estimated 4.5 million m^3 of forestry wastes currently used in small stoves or furnaces are probably providing only about 9.75 petajoules of thermal energy, whereas the same quantity of wood fired in larger, more efficient industrial boilers could provide 45.5 petajoules of thermal energy, with the possibility of simultaneous electricity generation as well.

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*Precedent exists for this type of arrangement, as some large firms do generate and sell surplus heat and power from company-owned and -operated facilities, although none of these are biomass-fired.

**Current lignite fired capacity is 7,258 MW. The above estimate assumes a dry lignite heating value of 12 gigajoules per tonne, a 32 per cent capacity factor and a 23 per cent conversion efficiency.

In specific cases, anaerobic digestion of livestock wastes may deliver mid- to long-term benefit streams as well. Depending on the condition and location of existing digesters, restoration of these units may provide employment, cost-effective on-site electricity generation and a by-product useful as fertilizer. In addition to displacing electricity supplied from the central grid, the reuse of digested manure as fertilizer can reduce inputs that may require chemical or petrochemical imports. Because agriculture is heavily subsidized, the resulting savings to farms should also represent savings to the Government.* Encouraging on-site energy production with a saleable by-product might improve the financial health of farmers and the Government at the same time.

Energy crops also represent a potential long-term economic benefit. Cultivation of energy crops would bring marginal land (degraded agricultural land or deforested land) into productive use. In addition to using idle land to provide a valuable commodity, energy crops have the added benefit of preventing erosion, thus preserving topsoil for future economic activity.

While the suggested biomass strategies offer economic returns related to specific industrial sectors and activities, biomass use has the potential to provide broad national economic benefits as well. The principal macroeconomic benefits associated with biomass development are job creation, efficiency improvements in related industries, hard-currency savings and stimulation of foreign investment.

High unemployment is and will continue to be a problem in Romania for the foreseeable future. In 1994 and early 1995 the jobless rate hovered between 10 and 11 per cent. The Ministry of Labour of Romania projects a rate of more than 14 per cent by the end of 1995 [35]. Large State-owned enterprises, characterized by inefficiency and unused capacity, still dominate the economy. As many of those enterprises are shut down or privatized, unemployment will worsen. Since 1989, agriculture has provided an important employment buffer, mitigating the impact of the drop in industrial output – the agricultural workforce grew by 400,000 people between 1990 and 1994. Nevertheless, the seasonality of agricultural labour and low farm incomes are probably masking a great deal of underemployment [37]. Development of markets for biomass fuels could provide additional work for seasonal agricultural labourers. For example, activities from collection and transport of orchard and vineyard prunings typically occur in winter months, providing a work opportunity during the slack time for agricultural employment. Forest-based residue collection may occur on a year-round basis, providing still more stable employment opportunities.

New jobs would be created in harvesting, collection and transport of the above-mentioned resources in rural agricultural and forested regions, as well as from the construction of new or upgraded biomass energy facilities. For example, an analysis of the potential economic impact of a typical 25-MW biomass power plant in the north-eastern United States estimated a potential net gain of 290 regional jobs associated with the development and operation of such a project [38]. In Romania, capital shortages might result in significant substitution of labour for capital across all sectors of the economy. If such is the case, Romanian biomass development might provide significantly more jobs than the United States example indicates.

The opening of the biomass energy market may also have beneficial economic effects on related industries. Though opinions vary widely on optimal forest management practices, forestry experts are becoming increasingly aware of the fact that opportunities to improve forest stands may expand with growth in fuel markets for low-grade forestry residues (tree tops and limbs, low-quality remnants of desired species, and low-quality timber species) [39]. Experience in the United States has shown that

*Interestingly, one of the largest agricultural subsidies is in the form of soft loans to livestocks producers, those most likely to benefit from biogas redevelopment.

markets for low-grade forestry wastes can encourage desirable forestry practices such as thinning and early stand releases, which augment forest growth and improve timber quality. In stands where these practices were previously not considered cost-effective, markets for residues have tilted the economic balance in their favour and improved forest health and timber quality in the process. If biomass use does encourage such forest management practices, additional job creation will follow. Increased labour inputs in forestry will be required, and resulting increases in residue volume could lead to job opportunities in handling and transport.

Biomass use could have positive trade implications as well. Romania is a net importer of both hard coal and electricity, thus any efforts to displace these imports with domestically produced biomass energy will improve the balance of payments of Romania and reduce its debt. Currently, Romania must borrow funds to finance its consumption of imported energy. The principal source of these loans is stand-by credits of the International Monetary Fund drawn on for energy imports to keep industries running and to cover balance of payments deficits. Increased use of indigenous energy resources could reduce the need of Romania to draw on these credits. If Romania developed only one third of the estimated 400 petajoules of its potential biomass energy, it could displace the equivalent of approximately 5.7 million tonnes of imported hard coal-worth about $228 million-or 2.7 million tonnes of imported crude oil, valued at about $351 million.*

Expanded biomass energy opportunities can also attract outside investments targeted towards capturing environmental benefits. One approach for fostering the development of biomass resources in Romania is to attract foreign investment through joint ventures to offset carbon dioxide emissions (referred to as "joint implementation" projects in the United Nations Framework Convention on Climate Change) by supporting biomass energy production in Romania, or by winning financial support for specific biomass energy projects through the Global Environment Facility that pays incremental project development costs associated with capturing environmental benefits. Both of these financing sources provide funding on a project-specific basis, as well as for a number of individual projects "bundled" into a larger project. Potential projects might include community district heating or combined heat and power projects that propose to replace fossil fuels with biomass energy resources in order to obtain the benefits of reduced carbon dioxide emissions. Such projects provide direct, quantifiable economic benefits to both project developers and the national economy by attracting foreign investment.

2. *Environmental benefits*

Industrial, utility and district heating uses of biomass energy offer benefits at the national level in terms of reduced combustion air emissions. Biomass energy offers one of its greatest environmental benefits from the potential to offset sulphur dioxide emissions. Public energy systems may be coordinated with environmental protection efforts to reduce sulphur emissions in high-pollution areas by displacing fossil fuels with biomass. Romania is currently attempting to acquire low-sulphur fuel oil (less than 1 per cent) to replace the use of high-sulphur fuel oil (up to 3.3 per cent) often burned by RENEL. Lignite and coal used in Romania are also high in sulphur content-ranging from 1.5 to 4 per cent [4]. Biomass energy resources have negligible sulphur content, and thus result in minimal sulphur dioxide emissions. Such emissions and the resulting acid-rain problems currently pose a threat to the health of the Romanian forests themselves.

Seven counties have at least one locality that exceeds maximum permitted sulphur dioxide emissions a part of the year. Four of these counties (Arges, Bacau, Maramures, and Neamt) are also four of the nine most forested counties. The county of Alba is slightly less forested, but its locality Zlatna,

*Assuming $40 per tonne of imported hard coal and $130 per tonne of imported crude oil [1].

which lies in the forested Transylvanian Alps of Romania, exceeds maximum permitted sulphur dioxide emissions for 22 per cent of the time (see figure XII.1) [17]. Nearby forests may prove to be viable sources of wood fuel to offset sulphur dioxide emissions. The reduced sulphur dioxide emissions would in turn reduce negative sulphur dioxide impacts on the surrounding forests.

Near-term biomass energy options can provide immediate environmental benefits in terms of reduced net greenhouse-gas emissions from energy production. A comparison of the combustion emissions from forest residues (from a sustainably managed forest) fed into a stoker boiler versus coal fed into a pulverized coal boiler shows that 986 tonnes of carbon dioxide per gigawatt-hour are emitted during coal combustion, whereas little over 1 tonne per gigawatt-hour is emitted from the wood-fired stoker boiler [40]. This assumes that sustainable biomass regrowth offsets biomass combustion emissions, resulting in no net emissions from biomass feedstock combustion. As of 1993, the estimated Romanian market for lignite for power generation was 34.5 million tonnes [4]. If wood resources were to offset up to 3 per cent of this lignite, they could reduce net carbon dioxide emissions by approximately 1.2 million tonnes annually.

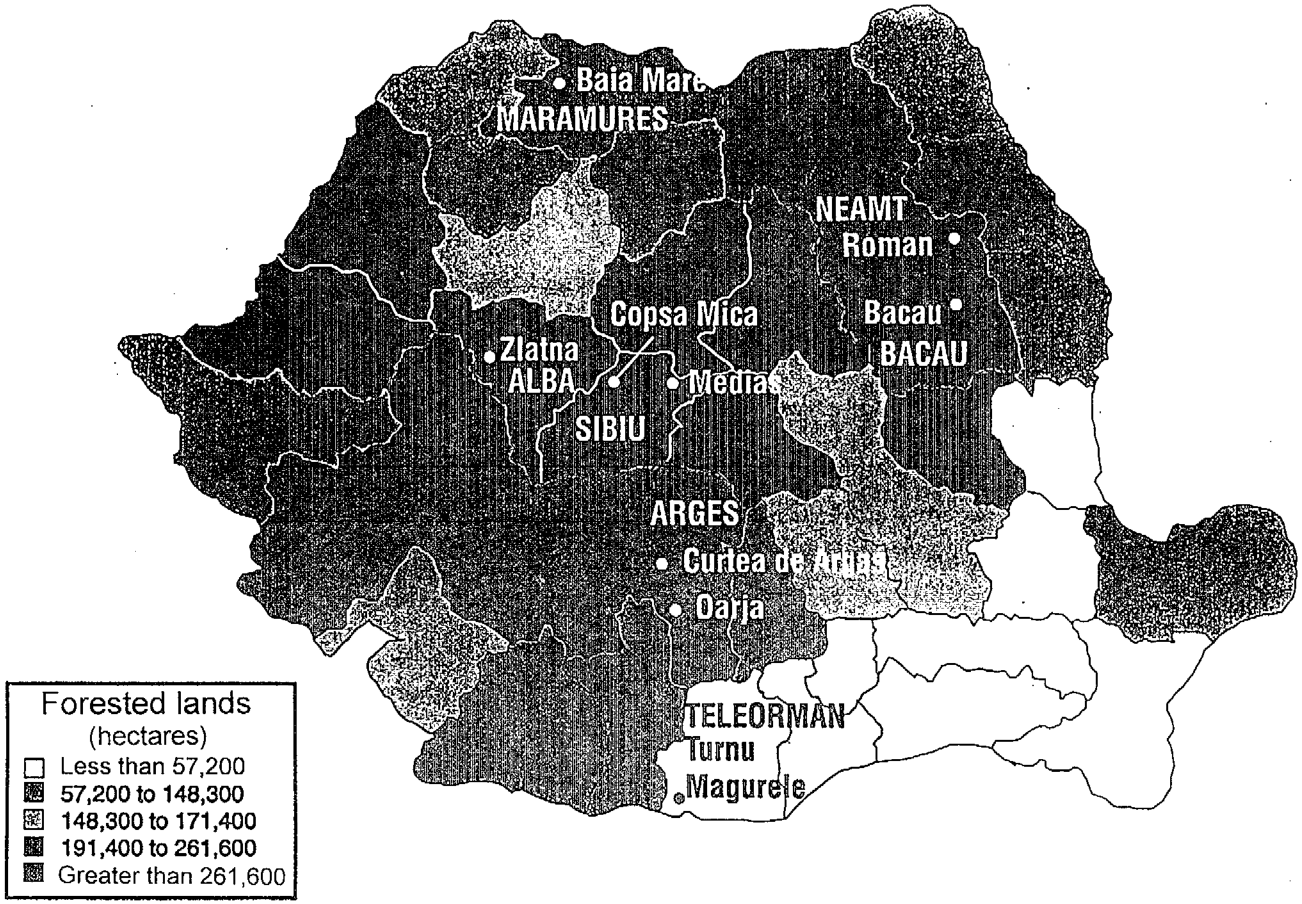
The potential upgrade of wood-fired small stoves throughout rural Romania would have the environmental benefit of improving the efficient use of indigenous renewable resources. In addition, the emissions per unit mass of wood burned in wood stoves versus industrial boilers with emissions controls is significant. As cook-stove efficiencies improve, and less wood is needed for residential applications, more wood can be redirected to cleaner-burning energy systems.

In the medium term, the direct capture of methane emissions through landfill gas collection systems or on-farm anaerobic digesters provides over 22 times the global warming benefit of offsetting carbon dioxide emissions (methane is 22 times as potent a greenhouse gas as carbon dioxide). Where manure is poorly managed, anaerobic digestion of livestock residues can also provide important health and environmental benefits by avoiding water contamination through run-off from pasture-lands or lagoons into surface waters or seepage into groundwaters. Furthermore, the argument is often made that manure left on fields provides a fertilizing benefit. In fact, the nutrients that enrich the soil are still in the digested manure, and are actually more effectively retained in the soil when the digested form of manure, which is also pathogen-free, is applied.

Some long-term biomass energy options also offer Romania environmental benefits. For instance, the establishment of energy crops on degraded or highly erodible lands can provide permanent or long-term cover and root mass, while still providing a steady stream of income from these fragile lands. In the United States, lands in the Conservation Reserve Program (established specifically to force overworked and fragile lands out of agricultural service for specified periods of time) have been found to be excellent lands for the production of fast-growing trees and grasses. On Conservation Reserve Lands taken out of annual production, the growth of trees or perennial grasses reduced the soil erosion rate by 92 per cent [24].

In Romania, 21 per cent of agricultural land is characterized by high to severe erosion (17-45 tonnes of soil per hectare per year), and about half of the agricultural land should be under protective conservation practices, according to erosion control experts [41]. A portion of this highly eroding land area overlaps with regions of Romania that are estimated to have considerable availability of land appropriate for production of energy crops (see figure XI.4) Over 400,000 hectares of highly erodible land in Romania may also be suitable for the production of energy crops.

Figure XII.1. Forested lands and localities exceeding sulphur-dioxide emission limits, 1993



XIII. ENERGY POLICY AND STRATEGY OBSERVATIONS AND RECOMMENDATIONS

In addition to the agricultural, forestry, environmental and social policies described in previous sections, Romanian energy polices and strategies are also in transition, and are likely to have the greatest impact on the ability to develop biomass energy resources. Three of the most important factors now in transition are the following:

(a) National energy policy and strategy;

(b) Electricity and Heat Law;

(c) Institutional issues in the Romanian energy sector.

A. Romanian energy policy and strategy

The current energy policy was presented to and approved by the Government in the spring of 1995. This energy policy is based on a RENEL strategy, and covers such topics as investment opportunities, prices and subsidies, and includes a strategy for heat production from co-generation. Government energy policies, however, continue to be in flux in Romania. In 1992, OECD conducted a thorough review of Romanian energy policies and made recommendations. Since that time, however, the Government of Romania has changed and approved the new 1995 energy policy, and is expected to change again in 1996. A stabilizing factor in the transition of the energy sector is the government acceptance of loans from multilateral funding institutions, such as the World Bank, which stipulate certain policy and structural changes as conditions to the loans.

The World Bank Power Sector Loan, for instance, is conditional on a study of options for the structure of the power sector that could result in changes to RENEL. This study is to be completed by the end of 1995, at which time the Government will then choose one of the options presented. A fuel options study is also being done as a requirement under the World Bank Power Sector Loan. This study will consider renewable resources in Romania, but the only form of biomass being considered is urban waste [42].

B. Electricity and Heat Law

The Electricity and Heat Law was originally written to be flexible enough to accommodate any potential changes resulting from ongoing studies on the structure of the power sector. Having proved to be too flexible, it has had to be rewritten by a team which included RENEL, the Ministry of Industries, the Ministry of Finance and others. The Electricity and Heat Law is now awaiting debate and approval by the Parliament of Romania. In the meantime, a government decision was issued in 1994 on production, transmission, distribution and use of electricity and heat [42].

One of the topics to be explicitly addressed by the Electricity and Heat Law is independent power production and associated issues such as retail sales and wheeling of electricity over transmission and distribution lines. Biomass resources are generated and managed by a dispersed set of industries, as opposed to fossil fuel and hydropower resources, which are managed almost entirely by and for the energy generation sector. Therefore, laws and regulations regarding the ability of the disparate biomass industries to enter into the energy market are key to the future of biomass energy development.

Currently, there are three types of electricity generation in the country: generation facilities owned by RENEL; independent power producers that are just appearing in Romania (only one is currently selling power to the RENEL electric grid); and self-producers, which already comprise about 4 per cent of total electricity generation. In concept, RENEL supports development of independent power producers, and according to the government decision issued in 1994, RENEL will buy any electricity produced at market price. While independent power producers will be encouraged under the new law, it is unknown to what degree biomass-fired industrial facilities will be able to compete with centrally generated electricity of RENEL. The possibility also exists that a separate renewable energy bill may be drafted, though as yet it is undetermined whether it will be introduced as a separate law, as part of the Electricity and Heat Law, or as an independent government decision [7, 42].

It is expected that the Electricity and Heat Law will give assurance of access to the grid to sell or transport electricity from a producer to a specified consumer (domestic or foreign), depending on a price determined under the contract of the producer with the grid owner. Electricity sales and transmission pricing is to be established through negotiations (between the Ministry of Finance and the Ministry of Industries) based on RENEL production costs [42].*

Self-generators of heat are much more abundant in Romania, though they are currently using most of the heat that they generate on site, and are not supplying heat to outside customers. Public heat is supplied through RENEL co-generation plants and district municipal plants. Nevertheless, heat supply in the winter is a problem: at temperatures below 5° C, some towns, including Bucharest, have difficulty meeting heating needs. In addition, the newer urban residential flats constructed during the past decade are poorly insulated, and were not designed according to energy efficiency principles. As a result, those flats consume three times more energy than comparable flats in western countries [42]. Large losses are also incurred throughout the transport mains in district heating systems, and rehabilitation of those systems will require huge investments. Independent heat producers do not really exist yet, but there are not likely to be any barriers to selling excess heat to a centralized heat supply system. The responsibility for transmission and distribution of heat belongs to municipal companies that may also increase the heat in the system if necessary. Companies producing excess heat could therefore sell to the municipality. Specific rules regarding contract and price negotiations are not expected to be developed in the near term, though a PHARE-sponsored study is currently under way to make an assessment of, and recommendations on, the district heating system in Bucharest. An energy efficiency law that may address some of the heating-related problems could also be drafted [7, 42].

C. Institutional issues in the Romanian energy sector

In Romania, the responsibilities of developing and implementing energy policy and strategies are divided among a number of separate and nested institutions. The Ministry of Industries is responsible for developing national strategies for all industries, except the food industry, and is divided into administrative and technical directorates-general. The Directorate-General for Energy, Oil and Gas is responsible for developing the strategy for the energy sector and coordination of three State companies: RENEL (the electric utility); ROMGAZ (the natural gas utility); and PETROM (the national petroleum company). The coal industry is handled under a separate directorate-general within the Ministry of

*RENEL, a regulated monopoly in power production, must achieve only minimum profits. The average price for electricity will be maintained at $50 per MWh, including value added tax, for commercial and industrial customers, while an electricity and pricing study is conducted by the Government of Romania and consultants [1].

Industry. The State will continue to have some involvement in companies that work in strategic areas, such as the three listed above, by approving budgets and strategies, appointing boards of administration, and approving investments [42].

The Romanian Agency for Energy Conservation (ARCE) was created in 1991 to provide a much-needed focus on alternative energy options, and is also located within the Directorate-General for Energy, Oil and Gas. Funds from the European Union have provided a vital influx of support to develop the strategy for renewable energy resources in Romania led by ARCE [7, 42].

ARCE sees the likely niche market for biomass resources to be rural applications through an approach referred to as "rural energetics" [7]. Under this approach, the provision of energy services is evaluated in conjunction with the multiple benefits that can be provided to rural populations. Biomass resources can generate energy, promote economic activity and provide environmental benefits in the context of the increasing rural migration supported by the new regime. Thus, it will be important to highlight the multiple benefits of rural biomass energy supply.

Unfortunately, the biomass advocates in ARCE and other institutions are faced with a bureaucratic structure that isolates them not only from potential rural energy consumers and biomass energy producers, but also from the government decision makers. Romanian villages coordinate with and report to a branch of the government focused on local initiatives, not to the Ministry of Industry where ARCE is located [7]. This presents bureaucratic hurdles in communicating with the providers and users of biomass resources on a decentralized level.

Furthermore, educating high-level government policy and decision makers who are now unaware of the importance of rural biomass energy resources and their multiple benefits is essential to achieving progress. ARCE does not enjoy direct access to the Government, however. It is forced to communicate through the national energy monopoly, RENEL, which has a strong natural gas and petroleum bias focused on maintaining as top priority the establishment of costly interlinkages with new natural gas suppliers, rather than tapping local resources such as biomass [7].

XIV. CONCLUSIONS

The future of biomass energy in Romania may require directed technology transfer and training to combat the bias against biomass energy, by addressing failed biogas and crop residue technologies; by educating industry about high-efficiency energy systems that could provide multiple benefits; by providing information on strong investment partners; by working with utility officials, local government decision makers and wood-industry managers to coordinate the management of wood fuel resources for public heat and power facilities, as well as residential uses; and by working with RENEL and potential private electricity and heat providers to facilitate project development.

In addition to the poor public perception of biomass energy in Romania, several other issues remain of particular concern for biomass development in Romania. The most important include: the reduction of land plots and farm units from very large to very small, which has an impact on the viability of biomass resource development and exploitation; the need for potential development partners for biomass energy projects; and persistent barriers to securing financing for biomass energy, given the prevailing emphasis on improving the infrastructure investments in fossil fuel and nuclear energy facilities. Romania is, however, beginning to receive support for much-needed economic feasibility studies through the Energy Efficiency Unit of the European Bank for Reconstruction and Development [7].

Romania is undergoing rapid transitions in a number of areas that could greatly affect the viability of biomass energy development, including: its economic structure; each of the industrial branches related to biomass energy resources and conversion; the legal framework determining participation in the energy industry; and the governmental offices and research institutes that are or have been charged with developing biomass energy. Whereas biomass may suffer from a poor performance record in Romania today, the country still has an extensive history of research on the subject and staff who have dedicated themselves to the topic for years, making Romania one of the leading countries using biomass for thermal energy production in eastern Europe. Numerous barriers to the successful development of biomass energy in Romania exist, but by focusing on the development of near-term biomass energy projects with high potential success rates, by accessing foreign investments targeted at energy and environmental opportunities, and by enhancing and upgrading existing energy systems that use or could use biomass resources, Romania could begin to rely on biomass as the solution to its energy supply shortages in niche, rural markets in the immediate future, and in broader applications over the coming decades.

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Part three

The Philippines
Country study*

Abstract

Biomass is organic matter produced in a renewable and sustainable manner, by plants through the process of photosynthesis. Biomass can be used as an energy resource to produce heat, power and transport fuels. The integration of biomass into a national energy supply mix may confer a number of local and national benefits. These benefits include displacement of imported fossil fuels with concomitant savings in foreign exchange, abatement of greenhouse gas release and possible reductions in levels of air pollution.

The present case study evaluates the status of energy development in the Philippines to determine current levels of biomass utilization and the potential to further develop and use indigenous biomass energy resources. The study is based on:

(a) Discussions held with representatives of the various agencies involved with biomass production and energy planning and programme implementation, during a brief mission to the Philippines;

(b) An evaluation of current conversion technologies and facilities with the potential to fully utilize available biomass resources in domestic, industrial and power generation sectors;

(c) An analysis of existing biomass production data, energy policies and plans, and projections for energy supply and consumption supplied by the relevant agencies and government departments of the Philippines.

The Department of Energy is responsible for development and management of national energy policy and programmes. They have prepared an energy policy and projections for energy supply and consumption for the period 1996 to 2025. Non-conventional energy resources have been given a high priority, and a separate programme has been developed under the administration of the Non-conventional Energy Division of the Department of Energy.

Total energy consumption in 1994 was estimated at 198 million barrels of fuel oil equivalent (BFOE). Imported fossil fuels accounted for 58 per cent of the total energy supply in 1994, biomass being the most important indigenous fuel source (28 per cent). The Department of Energy projects total energy demand to increase to 1,392 million BFOE, with imported fossil fuels continuing to supply 58 per cent. Although biomass energy consumption is projected to rise to 181 million BFOE by 2025, the proportion of supply is expected to fall to 13 per cent because of increased production of conventional indigenous energy resources.

A detailed analysis of selected biomass energy resources has been completed. It is concluded that the commercial potential exists to produce heat and power from residues of the sugar, rice and coconut industries. In addition, wood and wood wastes will remain a major energy resource for households and rural industry.

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XV. CONTEXT AND FRAMEWORK OF THE STUDY

A. The Philippines

1. Topography and population

The Philippines is the northernmost island group of the Malay Archipelago, extending about 1,850 kilometres almost due north and south between Borneo and Taiwan; the eastern and western extent is almost 1,127 kilometres. In general, the islands are all mountainous, with the ranges extending north to south paralleling the coasts and in many places bordering them.

The larger islands, particularly Luzon and Mindanao, have a diversified topography, with broad plains and level, fertile valleys in the interior providing extensive agricultural land. The Philippines, however, are renowned for the terraces on which rice is grown in the mountain areas.

The Philippines have a tropical climate with a mean annual temperature of about 27° C. This varies with location, proximity to the sea and altitude. Rainfall averages about 2,030 millimetres per year in the lowlands, with a rainy season from May to November. From June to October the Philippine Islands are sometimes struck by typhoons, which occasionally cause great damage.

The native people of the Philippines is called "Filipino". This term originally denoted a person of Spanish descent born in the Philippines. The present Filipinos are divided according to language and religion. The most important numerically are the Visayas, living primarily in the central portion of the archipelago, and the Tagalogs, in central Luzon. People of Spanish and Chinese descent constitute the chief non-Malay groups. In addition, people of mixed Filipino and White or Chinese descent form a small but economically and politically important minority.

Although Tagalog (Filipino) is the official language of the Philippines, English is commonly used for educational, governmental and commercial purposes. Spanish, formerly an official language, is spoken by a dwindling minority of the population.

Education in the Philippines is free and compulsory for children of ages 7 through 12. Almost 90 per cent of the adult population is literate, and approximately 1.1 million students attend universities and colleges.

The country is a Republic with the President-head of State and chief-elected by direct universal suffrage to a single six-year term. The legislature consists of two levels-a senate of 24 members, serving six-year terms, and a house of representatives with a maximum of 250 members, serving three-year terms. In mid-term elections during 1995, pro-government parties won a majority of Senate seats and maintained a dominance of the lower house.

2. Economic background: recent trends and prospects

The Philippine economy is emerging from the recession that developed toward late 1990, with two years of growth. In 1994, GDP growth was 4.3 per cent, and inflation fell to 9.3 per cent from the average of 11.7 per cent per annum for the period 1990-1994. This recovery was reflected in all sectors of the economy, with agricultural output increasing by 2.4 per cent, industrial growth by 6.1 per cent, manufacturing by 5.1 per cent and services by 3.8 per cent [1].

There was robust growth in exports and a sustained inflow of remittances by overseas workers leading to a positive trade balance [2]. Inflation continues to fall, and at 5.1 per cent in February 1995 was at its lowest since June 1987 [3].

The strength of the economy reflects the increased stability of the political climate, prudent macroeconomic management and improved investment infrastructure. The Government has met fiscal and budget targets agreed with IMF, and expects to maintain a balanced budget in 1995 and 1996, which will allow inflation to fall further (table XV.1). All of these factors have improved private-sector confidence in the Philippines. This is reflected in the considerable increase in consumer spending, the influx of foreign investment and the number of new business registrations with the Board of Investment.

Table XV.1. Projected macroeconomic indicators

Item	1994	1995[a]	1996[a]	1997[a]	1998[a]	1999[a]
Real GDP (million dollars)	4.3	5.4	5.6	6.0	6.0	6.0
Consumer price inflation (percentage)	9.3	8.5	7.5	7.4	7.0	7.0
Average exchange rate (pesos)	26.4	27.2	29.5	32.0	33.5	35.3
Treasury bill discount rate (percentage)	16.0	16.2	15.5	14.0	14.0	13.2

Source: The Economist Intelligence Unit, *The Philippines-Country Forecast 2nd Quarter 1995* (London, 1995).

[a]Forecasts.

The success of President Fidel Ramos in gaining a pro-government majority in the Senate suggests continued political stability and development opportunities at least until 1999 (table XV.1). The objectives of the national medium-term development plans for this period remain economic liberalization, tax and tariff reforms and elimination of shortfalls in physical infrastructure (transport and roads, communications and power supply). The objectives of industrial policy are to attract investment in areas that generate employment, exports, rural development and technology transfer, and contribute to the well-being of the economy.

The Board of Investment provides incentives to new businesses in priority sectors. Eligible businesses qualify for 100-per-cent duty exemption for imported capital equipment, tax holidays of 4 to 6 years and up to 100-per-cent foreign ownership. The Board of Investment publishes an annual listing of priority areas [4].

Alleviation of poverty remains a daunting challenge for the Government, particularly in rural areas and the agricultural sector [1]. These factors of high rural unemployment and poverty have exacerbated the drift from rural to urban areas, particularly Metropolitan Manila, placing additional strains on an already overstretched infrastructure in the capital.

The overall economic outlook for the Philippines is excellent, with an educated management cadre, a large pool of unskilled, but trainable labour, stable Government and access to international sources of finance. There are problems of high operating and infrastructure costs related to low labour productivity rates and comparatively high costs of labour, land, office rentals and electricity. If these are overcome, then the Philippines is in an ideal position to take its place alongside the leading economies of the Asian Pacific rim.

B. Biomass energy

Biomass is defined as organic matter produced either directly or indirectly by plants through the process of photosynthesis. Biomass energy is that energy derived from biomass either directly through combustion or indirectly through use of conversion techniques such as gasification, liquefaction, biomethanation and fermentation. Biomass resources in developing countries are summarized as: energy crops; agricultural and forestry residues (including livestock wastes); agro-processing and timber by-products and wastes; animal wastes and manure; and municipal solid wastes. The potential biomass energy resource represents a significant proportion of commercial energy demand in developing countries. Hall et al [5] estimate that the global potential sustainable biomass supply from residues is about 31.2 exajoules, or 10 per cent of world commercial energy use. Approximately half of these resources are available in developing countries, but represent a greater proportion of current energy demands.

The energy potential within the crop residues was estimated at 12.5 exajoules. Energy crops, if fully developed, were estimated at 266.9 exajoules per year, with 60 per cent available in developing countries.

Of the available biomass resources, it is considered that agro-processing and timber industry residues offer the earliest commercial opportunities for large-scale energy production because:

(a) The resource is usually dry or easy to dry and available in significant quantities in industrial locations ("at the end of a pipe");

(b) There are immediate industrial demands for heat and power;

(c) Processing units are often in peri-urban and rural areas where the price of fossil fuels is inflated by transport costs, and electricity costs are high because of transmission losses and capital charges;

(d) Residues and wastes have low-to-negative opportunity costs;

(e) Residues are often pollutants, and their disposal may cause environmental hazards;

(f) Costs of residues are also low, as there are no transport costs and storage and handling costs are minimal.

Overall, the efficient use of biomass residues in agro-processing and related industries offers real opportunities to reduce plant operation costs and thus improve commercial returns. This provides strong incentives for such industries to install biomass co-generation equipment, whenever and wherever possible.

In comparison, development of energy crops:

(a) Requires new plantation development and operation, often in areas traditionally served by subsistence methods;

(b) Takes a number of years to come into full production;

(c) Requires considerable capital investment in resource production, and thus has higher initial costs compared to process residues.

Agricultural and forestry residues have high potential for energy utilization, especially for small-scale operations and as informal domestic fuels. Although they have low in-field values, it requires effort, time and cost to collect, store, handle and transport them to markets. This often outweighs the final commercial benefit, particularly for low-value end-uses such as heat and power production. The potential benefits are even less in developing countries where agriculture is often at subsistence level, and densities of available residues are therefore low.

In developing countries, municipal solid wastes do not represent a major resource because population centres are usually highly dispersed, and there is little or no organized collection and treatment of urban wastes. Therefore, except for a few major cities in expanding economies, there is little incentive to utilize municipal solid wastes as fuel sources on a commercial scale.

The potential to use animal wastes and manure as energy resources through the production of biogas as a fuel for heat and power generation varies considerably between countries and social and cultural attitudes. In general, livestock production is often a smallholder and dispersed agricultural activity in developing countries. This reduces the overall opportunity, but important niche markets exist for combustion of solid wastes (chicken) and biogas production from liquid effluent from dairy and pig units in some countries.

The expanded use of biomass residues and increased familiarity with the successful operation of biomass-based combustion and co-generation equipment will increase confidence in the use of such resources. This should result in wider use of energy crops, animal wastes and agricultural and forestry residues as energy resources.

The use of biomass energy resources can be beneficial to national economies through a reduced reliance on imported and dwindling fossil fuel, foreign exchange savings, creation of local employment and wealth creation opportunities and a reduction in net release of greenhouse gases such as carbon dioxide and methane. The potential environmental benefits have increased the interest and support for the use of new and renewable energy resources by international development banks and national agencies.

Countries most likely to develop significant levels of biomass energy use are those characterized by some of the following:

(a) High levels of renewable biomass resource availability;

(b) Limited resources of indigenous fossil fuels;

(c) High demand for increased energy production, particularly electricity;

(d) Renewable energy policies and objectives with incentives for private power and renewable energy projects;

(e) Policies which promote or favour private power production and favourable power purchase agreements;

(f) Policies which support rural electrification and rural development;

(g) Support from international agencies, development banks and bilateral aid programmes.

The following study examines the energy sector in the Philippines to determine whether any of the above criteria are met and to establish the potential for biomass use as an energy resource in the near to medium term.

C. Objectives

The present case study evaluates the status of energy development in the Philippines to determine current levels of biomass utilization and the potential to develop indigenous biomass energy resources. The main objectives of the Philippines study are:

(a) To describe current and proposed strategies for the supply of primary energy resources to meet national energy demands;

(b) To establish current and future availability of indigenous biomass resources, including residues from agricultural and forestry production and processing operations;

(c) To identify appropriate biomass conversion technologies suitable for key energy markets and end-uses;

(d) To prepare comparative estimates of the potential economic and environmental benefits of current and proposed levels of biomass energy utilization;

(e) To indicate policy changes and institutional support mechanisms to promote commercially and technically viable biomass energy programmes and projects.

D. Approach

The case study has been prepared on the basis of information available through existing formal and secondary literature sources and obtained during a brief mission to the Philippines. Discussions were held with representatives of government departments, peristatal agencies, commercial groups and international organizations involved with biomass production, energy planning and programme implementation.

Details of existing biomass production data, energy policies and plans, and projections for energy supply and consumption supplied by the relevant Philippines organizations were obtained for subsequent analysis.

Analyses have been completed on the basis of primary energy supply because of the wide variation in efficiencies between conversion technologies and energy sources. For consistency with data collection and presentation in the Philippines, energy units of barrels of fuel oil equivalent (BFOE) have been used throughout. A BFOE contains 6.25 gigajoules of energy.

Current and proposed primary energy supply and demand matrices, energy policies and strategies and biomass energy sources have been described, as well as current institutional arrangements for development of biomass energy technologies. For selected resources and end-uses, analyses of biomass availability and possible utilization levels were drawn up for comparison with projections prepared by the Department of Energy of the Philippines for the period 1996-2025 [6]. The basis of the main UNIDO projections are summarized in the energy conversion rate section and described in the relevant sections of the case study.

Estimates of foreign exchange savings and reductions in carbon dioxide emissions through the displacement of imported fossil-fuel sources are used as an indication of national benefits accruing from biomass resource utilization. These preliminary estimates were prepared for comparison only, as they are based on crude national data and ignore the fuel displaced and both foreign exchange costs and carbon dioxide emissions related with biomass resource production and conversion.

The foreign exchange value of biomass was based on its energy content and the assumption that all biomass energy resources displace imported fuel sources. A BFOE is calculated to $18.96. Similarly, it is assumed that biomass energy resources will displace an equivalent primary energy value of fossil-based fuels. A barrel of fuel oil is calculated to release 0.484 tonne of carbon dioxide on combustion.

A preliminary evaluation of key constraints to development of biomass resources was prepared on the basis of discussions held in the Philippines as a guide to further action required to promote and stimulate appropriate biomass energy technologies.

XVI. ENERGY DEVELOPMENT IN THE PHILIPPINES

A. Background

The Government of the Philippines has placed a high priority on the establishment of stable, secure supplies of energy, particularly electricity, to fuel the continued economic development of the country. Power demand has grown sharply in the Philippines and, with expanded economic activity, this growth is expected to continue. The national grid, however, has not grown at the same pace. From 1992, major electricity shortages placed a further strain on the development process. At the height of the power crisis in 1993 there were daily brownouts of up to 12 hours. The World Bank estimated that this caused economic losses of up to $600 to $800 million per year.

In 1993, the Government initiated a policy to improve the power supply rapidly with a harsh but necessary programme. The main elements of the programme were:

(a) To eliminate power outages by encouraging foreign companies to invest in the electricity generation sector so as to achieve the immediate addition of up to 1,500 MW;

(b) To increase base-load capacity by 21 gigawatts by 2005;

(c) To reduce dependence on oil by switching to alternative indigenous feedstocks;

(d) To continue deregulation of power industries with greater involvement of the private sector;

(e) To pursue an energy conservation programme.

The Government promoted fast-track development of a conventional base-load generation plant by the public and private sectors to meet the power demand. This programme allowed foreign companies to submit unsolicited bids for a new power plant and to negotiate purchase agreements with the National Power Corporation (NPC) rather than to follow competitive bidding procedures. This innovative programme for Build, Own and Transfer (BOT) and Build, Own and Operate (BOO) schemes by the private sector added 2,243 MW of new capacity by the end of 1994, with a further 2,000 MW of capacity being under construction [6, 7].

The above-mentioned measures demonstrate the ability of the Government of the Philippines to sharp and decisive action to achieve its objectives. The administration of, and policies and long-term plans for, energy development are presented in the following sections to establish the context for subsequent biomass resource utilization.

B. Energy agencies and related institutions

1. Department of Energy

In December 1992, the Department of Energy (DOE) was established to support and administer energy matters. DOE is responsible for the formulation of energy policy and the preparation and submission of long-term national energy plans for approval by Congress, on an annual basis.

Implementation of the energy programme is the responsibility of a number of national agencies and organizations coordinated and monitored by DOE.

The Secretary of DOE is a member of the board of other key energy-related organizations to ensure coordination and uniformity of the planning and implementation process. These agencies include the Philippines National Oil Company, the National Power Corporation and the National Electrification Authority. DOE is a member of the Energy Regulatory Board, which is based in the Office of the President and responsible for establishing energy pricing levels. The main divisions of DOE are the Energy Resources Development Bureau, the Energy Industry Administration Bureau, the Energy Planning and Monitoring Bureau and the Energy Utilization Management Bureau. The Non-conventional Energy Division (NCED) is part of the Energy Utilization Management Bureau.

2. Non-conventional Energy Division

NCED is mandated to manage the Non-conventional Energy Programme, which was formulated to ensure the promotion and commercialization of non-conventional energy resources and technologies. NCED seeks to develop those systems which are technically feasible, socially desirable and economically viable.

NCED works within the following three main programmes:

(a) Technology improvement - to improve the techno-economic efficiency of non-conventional energy systems;

(b) Promotion and commercialization - to create a favourable market environment for a non-conventional energy industry;

(c) Affiliated Non-conventional Energy Center (ANEC) programme - to establish a mechanism to promote non-conventional energy use in rural and remote areas.

NCED does not carry out research and development (R and D) programmes. These are the responsibility of the Department of Science and Technology and its associated research organizations. DOE and NCED establish the priority research areas, and thus direct research efforts. NCED is directly involved in the demonstration and commercial promotion of technologies after the R and D phase. The projects are conducted in cooperation with a number of national institutions. Technology diffusion is a key area, and NCED works closely with non-governmental organizations, international agencies and commercial groups to disseminate information, support training programmes, and establish linkages with local and international agencies.

NCED has established a major survey programme to determine the level of non-conventional energy use within the country. This is done in association with the ANECs and international groups. A biomass energy survey is currently under way with support from the Asian Institute of Technology. It covers biomass resource supply and utilization and technology development and availability. The results of the survey are expected at the end of 1995.

NCED is also the focal point of the Regional Wood Energy Development Programme.

3. Affiliated Non-conventional Energy Centers

NCED established a network of ANECs in strategically located universities and agricultural colleges in various regions of the country. ANECs are the eyes, ears and arms of NCED, allowing direct contact with rural and remote communities throughout the country. ANECs conduct rural energy surveys and develop local rural energy plans. ANECs also provide technology support for non-conventional energy projects in their region, training and assistance in installation and operation of specific technologies, such as domestic biogas units.

4. Energy Industry Administration Bureau

The Energy Industry Administration Bureau (EIAB) is the section of DOE responsible for policy and relationships with independent power producers. This bureau within DOE was established to accredit new private power projects. All independent power producers who are to sell power to third parties must be accredited. Self-generation projects must also obtain accreditation if they are to be registered with the Board of Investments and thus benefit from a range of investment incentives.

New power projects must be in accord with the overall systems planning of NPC. Independent power producers are encouraged to bid for identified power projects, usually in competition for non-renewable resources. Project proposals based on renewable resources may, however, be submitted without a bidding process.

EIAB has 60 days (two months) to evaluate project proposals. Initial proposals need only provide details of the proposed company structure, project location and an outline of the resource base, general plant description and operation, manpower and intended purchaser. This will be evaluated for technical and economic relevance by EIAB.

Once conditional accreditation has been given, the proposers have one year to obtain finance, negotiate a purchase contract with NPC or a private utility, and obtain an environmental impact permit from the Department of the Environment and Natural Resources (DENR). If all those conditions are met, then final accreditation will be provided and the project can proceed.

In addition to avoidance of the tendering and bidding process, projects based on renewable resources also benefit from relaxation of the requirement for at least five years of experience as generators and of the need to maintain a spinning reserve and to meet the criterion of 60 per cent thermal efficiency. In addition, NPC is to prepare a standard power purchase agreement for small projects (below 10 MW) to reduce the time and expense related to contractual negotiations [8]. Should disputes arise, the Energy Regulatory Board (ERB) is the final arbiter concerning implementation of the regulations.

EIAB is also required to formulate a standard methodology to calculate avoided cost benefits. A consultant was to submit a report on the methodology before the end of 1995.

EIAB has accredited a number of projects based on renewable resources. These include the BUSCO sugar-milling co-generation plant (8 MW) and a 35 MW proposal for energy from rice hulls.

5. Energy Regulatory Board

ERB is an independent body, in the Office of the President, charged with the task of achieving more coherent and effective policy formulation, coordination, implementation and monitoring within the energy sector. ERB has the responsibility to fix and regulate prices of petroleum products, gas and power purchase agreements. At times of petroleum shortages, ERB may adjust the level of petroleum product prices and payment to the Oil Price Stabilization Fund, to encourage fuel imports.

6. *Board of Investments*

The Board of Investments (BOI) of the Department of Trade and Industry provides incentives to priority investment areas. Industries that register with BOI are eligible for a range of incentives. The level of incentive depends on the classification of the industry. Industries are classified as either pioneer or non-pioneer. Independent power projects using coal and non-conventional energy sources and projects of over 50-MW capacity classify for pioneer status.

The main incentives include:

(a) A four-year (non-pioneer) or six-year (pioneer) income tax holiday;

(b) Exemption from duty for imported capital equipment;

(c) Foreign ownership for pioneer industries.

7. *National Electrification Administration*

The National Electrification Administration (NEA) is a government-owned and -controlled corporation responsible for development of rural electrification programmes and for provision of technical, financial and administrative support to the Rural Electricity Cooperatives (RECs). RECs distribute power to rural communities throughout the Philippines. NEA has particular interest in promotion of solar energy systems and mini-hydropower installations. Twenty mini-hydropower units have been installed, and a further 104 units (51-MW capacity), provided by bilateral aid donors, are still to be installed. Potential sites have been identified, but there is a lack of funds to maintain the programme.

NEA was also responsible for implementation of an earlier dendrothermal power programme, in which plantations of fast-growing coppice were to fuel 3- to 5-MW power plants. The programme failed through a loss of political and financial support following a change of administration. NEA acknowledged that such wood-based power appeared to be commercially feasible, but problems of land ownership, logging bans, petty larceny and cultural problems mitigate against future successes.

8. *National Power Corporation*

The National Power Corporation (NPC) is a government-owned and -controlled corporation responsible for generation and distribution of electricity to private utilities and to RECs. NPC establishes national plans for developing power generation facilities and promoting the participation of the private sector in power production [9]. It is also responsible for preparation of supply and purchase contracts with accredited independent power producers.

NPC has an interest in development and implementation of viable wind and solar energy projects as part of its mandate to establish new business enterprises. The selection of such enterprises is based on the perceived commercial opportunity.

The Government is committed to privatization of NPC in the near term.

9. *Philippines National Oil Company*

The Philippines National Oil Company (PNOC) is a Government-owned and -controlled corporation charged with provision and maintenance of an adequate supply of petroleum products and promotion of exploration, exploitation and development of local petroleum and geothermal resources. The responsibility of PNOC has been expanded to include development of non-oil energy sources. The Energy Research and Development Center (ERDC) of PNOC takes an active role in research and commercial development of new and renewable energy resources and technologies. Biomass is considered to be a potential commercial business opportunity. ERDC has funded a detailed technical and economic evaluation of power generation from rice-hull waste produced by a cluster of mills. The results of that evaluation were not available for inclusion in the present study.

10. Department of Science and Technology

The Department of Science and Technology (DOST) is mandated to formulate and implement policies, programmes and projects for development of science and technology within the Philippines. Primarily, DOST provides central direction, leadership and coordination of R and D activities, and ensures that results are utilized in areas of maximum economic and social benefit.

The Philippines Council for Industry and Energy Research and Development (PCIERD) is the central council for allocation of national priorities and identification and allocation of funds to approved research areas. Funding is predominantly from the Government, with approximately 20 per cent from the private sector.

Implementation of specific programmes and projects is the responsibility of a number of DOST research institutes, universities and a mix of private groups. Recent biomass research projects are listed in Table XVI.1.

NCED is responsible for definition of priority research areas for non-conventional energy resources and technologies. These priorities are presented through PCIERD to DOST for development and allocation of R and D programmes. DOE is then responsible for commercialization and dissemination of successful technologies.

The Industrial Technology Development Institute (ITDI) is the main DOST focal point for energy R and D. The Fuels and Energy Division of ITDI conducts studies on production of liquid, gaseous and solid fuels using locally available materials. The Fuels and Energy Division is also one of the agencies responsible for developing appropriate biomass energy conversion technologies [10-12] and evaluating technologies introduced under the conditions prevailing in the Philippines [13].

The Fuels and Energy Division has completed work on combustion, gasification, carbonization and briquetting techniques for biomass fuels. It has expertise in these areas, and is seeking manufacturing support for developed technologies. These include a rice-husk gasifier-combustor, rice-hull domestic stoves and a wood-waste gasification pilot plant for electricity generation. Future programmes are designed to develop expertise in flash pyrolysis of municipal wastes and thermochemical conversion of biomass to oil (liquefaction).

DOST and the research community in the Philippines have a wealth of experience and skills in biomass conversion technologies. The major problem identified is the lack of government funding to adequately support R and D efforts and manufacturing and commercialization of successful equipment and technologies.

11. Forest Management Bureau of the Department of the Environment and Natural Resources

DENR is the government department responsible for monitoring national environmental policy and protection standards. The department is responsible for issuing environmental compliance certificates

Table XVI.1. Selected biomass energy R and D projects, 1987-1994

Programme/project	Agency	Duration
Production, usage and determination of the long-term viability of ALGAS as a motor-vehicle fuel	DOST-TAPI	1987/88
Production, usage and determination of the long-term viability of ALGAS as a motor-vehicle fuel	DOST-PCIERD	1988/89
Technology transfer of small-scale production of methyl esters as diesel substitutes	DOST-PCIERD	1992/93
Demonstration of coconut methyl ester	NPC/PCA DOST-ITDI	1991
Coconut methyl ester pilot R and D project	PCA	1994-2000
Rice-hull gasifier combustor for oil extraction	DOST-ITDI	..
Gasifier combustor for paddy-drying	DOST-PCIERD	1989/90
Technology dissemination on rice-hull gasifier for brick-making	DOST-PCIERD	1994
Performance testing on a rice-hull combustor gasoline-engine system	DOST-ITDI	..
Fluidized-bed gasification of wood waste for power generation	DOST-ITDI	to 1993
Pilot testing of wood-waste gasification	DOST-ITDI	1994/95
Demonstration project on gasification of densified rice hulls	NCED/PNOC-ERDC	1983-1987
Pyrolysis of cellulosic wastes in fluidized-bed.system for co-generation	DOST-PCIERD-UP-Laguna	1990-1994
Prefeasibility study of pyrolytic gas utilization from coconut shell carbonization	DOST-PCIERD	1991
Extraction and use of pyrolytic gases from coconut shell carbonization for power generation	PCA	1994-2000
Design and development of a continuous rotary carbonizing kiln for sawdust and other particulate biomass wastes for production of charcoal briquettes	DOST-PCIERD-UP-Laguna	1993-1995
Development of fast-drying systems for coconut meat	DOST-PCIERD	..
Mass production of the ITDI rice-hull stove	DOST-PCIERD	..
Development of technology to optimize biogas production from distillery slops	DOST-PCIERD	1989/90
Biogas generation from cassava-starch processing waste	DOST-PCIERD	1990-1993
Integrated resource recovery from landfill	DOST-PCIERD	1991-1994
Study on biomass equipment suppliers	EDUFI	1992
Study on biomass co-generation potential in the Philippines sugar milling industry	EDUFI	1992-1994
Electric power supply agreement between NPC and sugar mills	EDUFI	1994
Various demonstrations of the rice-hull gasifier combustor in selected industries	ITDI	Ongoing
Commercialization of biomass-fired furnace	PADISCOR	1986-1994

Source: R.E.T. Quejas, Director of NCED, DOE, 1995.

for new project developments, such as heat and power production proposals. An environmental impact statement must be completed for all new projects, to demonstrate that the activity will not have an adverse effect on the environment [14].

The Forest Management Bureau (FMB) is a division of DENR with responsibility for issuing timber license authorizations to prospective timber operators. The number of authorizations has been reduced from over 100 during the 1980s to 32 in 1995. FMB maintains a number of regional offices to monitor forestry activity and produce detailed forest industry statistics. It considers that there are no strains on timber supply for domestic fuelwood and charcoal production. Fuelwood is supplied through a mix of forest residues and material from the harvesting of branches and coppicing of trees on agricultural land and from small woodlots.

Exports of lumber are banned except from managed plantations. The Government is providing incentives to develop industrial forest plantations. These include zero rent for 5 years, export allowances and a four- to six-year tax holiday. Over 200 agreements under the Industrial Forest Management Programme have been issued, and an initial $25 million loan has been obtained from the Asian Development Bank to on-lend to holders of Industrial Forest Management agreements.

FMB considers that there would be no major environmental restrictions on development of timber as an energy resource for future power production plants.

12. Energy Development and Utilization Foundation

The Energy Development and Utilization Foundation (EDUFI) is a private energy consultancy established to promote non-conventional energy resources. EDUFI is the implementation agency of the Philippines for the following three key international renewable energy programmes:

(a) The European Community/Association of South-East Asian Nations COGEN (EC/ASEAN COGEN) programme funded by the European Community to promote biomass co-generation technology transfer and development of selected commercially available technology;

(b) The Renewable Energy Project Support Office funded by Winrock International to provide technical and financial support for developers to identify and evaluate opportunities for renewable energy projects;

(c) Preferred energy investments-a related activity providing equity and loan financing for identified commercial projects.

EDUFI has completed evaluations of the potential for co-generation from biomass wastes in the sugar and rice industries, and is assisting the Sugar Millers Association in negotiation of a standard power purchase agreement.

Two co-generation projects have been proposed for funding under the EC/ASEAN COGEN programme. They are based on rice hulls, and are scaled at 800 kW and 400 kW of installed capacity.

13. Philippines Businesses for the Environment

Philippines Businesses for the Environment (PBE) is a non-stock, non-profit organization incorporated in 1992 to assist Philippines businesses in addressing environmental issues and concerns. One of its main activities is the Industrial Waste Exchange Programme, in which the wastes of one industry could be a raw material for another. This programme incorporates a database of waste material types and availability. The database could be a useful resource to identify commercial sources of biomass for future energy conversion.

PBE publishes details of recent activities and listings of companies in their database in a bimonthly magazine circulated to member companies and interested groups. Details of the main companies in their database and the available waste materials are included in this magazine [15].

PBE could play a useful role as a non-governmental organization promoting biomass energy technologies in Philippines businesses and providing information on commercial waste resources for energy production.

C. Energy policy

DOE is mandated to prepare and submit medium-term energy plans to the Government for approval on an annual basis. Plans have been developed for the periods 1993-2000 and 1994-2010, and a plan for 1996-2025 was submitted to the Congress of the Philippines in October 1995. Since the latter plan was unfortunately not approved for general release during the UNIDO mission, only parts of it could be highlighted in the case study.

The energy plans provide a long-term perspective to national energy needs, and identify the requirements, both financial and infrastructural, for implementing specific strategies and programmes. Targets for DOE and related energy agencies are set by the plans, thus stimulating departmental activity.

The overall objective of energy policy is to provide adequate, reliable and affordable energy to industries to enable them to provide continuous employment and low-cost goods and services, and to domestic consumers to enable them to achieve decent lifestyles. This should be done with due consideration to environmental concerns and sustainable use of the natural resources of the country, while maintaining its overall international economic competitiveness [5].

DOE is mandated to meet the above-mentioned objectives through the following actions:

(a) Formulation of clear policies and responsive plans and programmes;

(b) Intensive development of indigenous energy sources;

(c) Effective coordination of downstream energy activities;

(d) Judicious conservation and efficient utilization of energy;

(e) Close coordination and cooperation with other government agencies and private-sector organizations.

The most recent energy plan aims at achieving sustainable energy supplies that are competitive, affordable and compatible with the social and environmental aspirations of the country. The policies promoted by the plan may be summarized as follows:

(a) To increase energy self-sufficiency through continued exploration, development and exploitation of indigenous energy resources;

(b) To diversify both local and imported energy sources;

(c) To pursue large-scale use of new and renewable energy sources;

(d) To promote efficient energy management systems to conserve energy resources;

(e) To encourage greater private-sector investment and participation in all energy sectors;

(f) To integrate social and environmental concerns into the planning and implementation process;

(g) To develop and maintain energy information systems to support the planning process.

The above-mentioned broad policy objectives have been used to develop long-term projections for energy demand and supply options. These will continue to be refined, on an annual basis, through confirmation of near-term developments and re-evaluation of requirements for finance, infrastructure support and training.

A national non-conventional energy programme has been formulated to accelerate development, utilization and commercialization of new and renewable energy resources and technologies. Immediate goals of the programme are as follows:

(a) Support for technological R and D activities;

(b) Promotion of proven uses of non-conventional energy resources;

(c) Assistance to the private sector in the manufacture of commercial energy equipment and devices;

(d) Creation of a favourable market environment for both buyers and sellers of renewable energy systems;

(e) Development of area-based energy planning and management systems;

(f) Support for environmentally-friendly, commercial-scale, non-conventional energy projects;

(g) Strengthening of private-sector participation in the development of non-conventional energy resources;

(h) Development of appropriate databases on non-conventional energy resource supply and utilization and technology and market assessments.

NCED is responsible for the management of the programme.

D. Energy demand and supply projections

The energy plan has been prepared in accordance with the economic targets set in the medium-term development plan for the Philippines. Expected growth rates in GDP and energy demand are summarized in table XVI.2.

Table XVI.2. Projected growth of gross domestic product versus total energy supply
(Percentage)

Period	GDP	Energy	Electricity	Petroleum	Coal	Natural gas
1996-2005	7.2	7.1	12	6.4	14.9	16.5
2006-2015	7.2	6.4	8.7	8.7	11.5	8.7
2016-2025	6.3	5.9	6.7	5.3	5.9	7.6
1996-2025	6.9	6.6	9.2	6.2	10.0	11.0

Source: Department of Energy, *Philippines Energy Plan 1996-2025* (Manila, 1995).

Gross energy demand is projected to increase from 219 million BFOE in 1996 to 403 million BFOE in 2005 and 1,392 million BFOE by 2025 (table XVI.3A). These demand levels are driven, primarily, by a substantial increase in power generation to meet expected industrial demand and by an expanded domestic consumer base. Although efforts to intensify the use of indigenous energy resources will be sustained throughout the planning period, the rapid growth in energy demand necessitates the greater use of imported oil and coal (table XVI.3B). DOE stresses, however, the high level of uncertainty towards the end of the extended planning period and the possibility of refining the levels of supply and the content of the fuel mix as developments are confirmed.

A brief summary of current energy resources and plans for their development is presented to indicate the opportunities for promoting biomass energy use.

Table XVI.3. Projected energy supply and demand mix
(Million BFOE)

Item	**1996**	**2000**	**2005**	**2010**	**2015**	**2020**	**2025**
A. Total primary energy supply mix							
Indigenous energy	**99**	**126**	**192**	**235**	**1,317**	**428**	**573**
Conventional	**37**	**56**	**108**	**132**	**91**	**265**	**359**
Oil and gas	3	7	37	42	62	106	153
Coal	10	14	26	34	60	72	94
Hydropower	9	11	20	23	28	34	40
Geothermal	15	24	25	33	41	53	72
Non-conventional	**62**	**70**	**84**	**104**	**126**	**162**	**214**
Total biomass	62	70	83	102	123	148	181
Other	0	0	1	2	3	14	33
Imported energy	**121**	**176**	**212**	**317**	**451**	**627**	**818**
Oil	109	143	163	235	295	390	489
Coal	12	33	49	82	156	237	303
Nuclear	--	--	--	--	--	--	26
Total energy	**220**	**302**	**404**	**552**	**768**	**1,053**	**1,392**
Energy consumption	2	10	19	24	33	44	59
Energy less consumption	218	292	385	528	735	1,009	1,343

Item	1996	2000	2005	2010	2015	2020	2025
B. Primary energy sources as a percentage of total energy supply							
Indigenous energy	**45**	**42**	**47**	**43**	**41**	**41**	**41**
Conventional	**16**	**19**	**27**	**24**	**25**	**25**	**26**
Oil and gas	1	2	9	8	8	10	11
Coal	4	5	6	6	8	7	7
Hydropower	4	4	5	4	4	3	3
Geothermal	7	8	6	6	5	5	5
Non-conventional	**28**	**23**	**21**	**19**	**16**	**15**	**15**
Total biomass	28	23	21	18	16	14	13
Other	--	--	--	--	--		2
Imported energy	**54**	**58**	**53**	**57**	**59**	**59**	**59**
Oil	49	47	40	42	38	37	35
Coal	5	11	12	15	20	22	22
Nuclear	--	--	--	--	--	--	2
Total energy	**100**	**100**	**100**	**100**	**100**	**100**	**100**
Energy consumption	1	3	5	4	4	4	4

Source: Department of Energy, *Philippines Energy Plan 1996-2025* (Manila, 1995).

E. Current energy resources

The Philippines is highly dependent on imported fossil fuels for its energy needs, with oil and coal accounting for 74 per cent of commercial fuel consumption during 1994. If estimated fuelwood use in domestic households is included in total energy consumption, then indigenous energy sources meet approximately 48 per cent of 198 million BFOE (table XVI.4). Non-conventional energy sources, predominantly biomass, account for 67 per cent of indigenous energy resources. In 1994, 35 per cent of commercial energy consumption was used for power generation, with oil and gas fuelling 56 per cent of electricity produced [16].

Table XVI.4. Primary energy consumption, 1994

Item	Commercial energy		Total energy	
	Million BFOE	Percentage share	Million BFOE	Percentage share
Indigenous energy	**41.6**	**26.6**	**83.1**	**41.9**
Conventional	**27.5**	**17.6**	**27.5**	**13.9**
Oil and gas	0.6	0.4	0.6	0.3
Coal	5.9	3.8	5.9	3.0
Hydropower	10.1	6.4	10.1	5.1
Geothermal	10.9	7.0	10.9	5.5
Non-conventional	**14.1**	**9.0**	**55.6**	**28.0**
Total biomass	13.5	8.6	55.0	27.7
Other	0.6	0.4	0.6	0.3
Imported energy	**115.1**	**73.5**	**115.1**	**58.1**
Oil	112.2	71.6	112.2	56.6
Coal	2.9	1.9	2.9	1.5
Total energy	**156.7**	**100.0**	**198.2**	**100.0**
Power use	53.9	34.4	53.9	27.2

Source: Department of Energy, *Philippine Energy Bulletin-January-December 1994*, vol. III (1995).

1. Oil and gas

Total oil imports into the Philippines were 116.9 million barrels, an increase of 9.3 per cent from 1993 (table XVI.5). The major increase, however, was in the level of petroleum products, particularly fuel oil for power generation.

Table XVI.5. Petroleum imports

Item	Volumes (million barrels)			Cost (c.i.f.)	
	1994	1993	Percentage change	1994 total (million dollars)	1994 (dollars per barrel)
Total imports	**116.9**	**107.0**	**9.3**	**1,984.4**	**16.97**
Crude	**87.7**	**83.7**	**4.7**	**1,400.3**	**15.97**
Products	**29.2**	**23.3**	**25.3**	**584.1**	**20.00**
Diesel	14.2	15.8	-10.1	..	..
LPG	4.3	4.4	-2.3	..	..
Fuel oil	6.8	1.9	257.8	..	..
Other	3.9	1.2	225.0	..	..

Source: Department of Energy, *Philippine Energy Bulletin-January-December 1994*, vol. III (1995).

The average c.i.f. cost of crude oil in 1994 was $15.97, and that of products $19.97, with a mark-up of $4.00. The landed cost of crude oil for May-June 1995 was $17.66 per barrel, or 455.03 pesos per barrel. Since a barrel of oil has an energy content of 5.82 gigajoules, on an energy basis the equivalent landed-cost value of a barrel of fuel oil equivalent (6.25 gigajoules) amounts to $18.96, for future calculations.

Retail prices of refined products are supported through an oil price stabilization fund monitored by DOE. This fund is used to maintain posted wholesale and pump prices at an agreed level. There was considerable debate on the listed price of petroleum products, with the Government, against significant opposition, proposing a small price hike. Posted retail prices of main fuels in Metropolitan Manila for May 1995 are summarized in table XVI.6.

Table XVI.6. Petroleum product prices in Metropolitan Manila, May 1995

Item	Product price build-up (Pesos per litre)			
	Wholesale	Oil stabilization fund	Haulage/dealers mark-up	Pump price
Premium gasoline	8.6893	(0.3559)	0.66	9.00
Unleaded premium	9.2539	(0.9205)	0.66	9.00
Kerosene	6.3677	0.1049	0.53	7.00
Diesel oil	6.8431	(0.3865)	0.54	7.00
Fuel oil	4.6212	(1.9694)	..	2.65
LPG	8.0234	(2.7683)	..	5.26

Source: Department of Energy, *Philippine Energy Bulletin-January-December 1994*, vol. III (1995).

The level of domestic oil production in 1994 was 1.7 million barrels, a drop of 52 per cent on 1993 production. The Government is making considerable effort to develop oil and gas fields, with 22 survey contracts awarded in 1994 and 11 wells drilled. Current commercial reserves are considered to be at least 100 million barrels, and current production is 17,000 barrels per day. Further discoveries have been made, unfortunately in deep water requiring extra time and capital to develop [17].

Significant levels of oil and natural gas have been identified, with reserves in the Camargo-Malampaya field of 2.4-4.1 thousand billion cubic feet. A major pipeline to transport gas from the Shell/Occidental gasfield at Camargo-Malampaya to Metropolitan Manila has been approved. The joint venture between Shell Exploration and Occidental Philippines is negotiating supply contracts to provide gas to NPC to fuel up to 3,000 MW of generating capacity by 2001-2002 [18].

2. Coal

In 1994, a total of 1.58 million tonnes of coal (5.91 million BFOE) were produced in the Philippines, with proven reserves of 384 million tonnes. The energy plan projects that production will increase to 27.8 million tonnes, or 98 million BFOE, by 2025, with a corresponding increase in proven reserves to 1,132 million tonnes.

3. Hydropower

Hydropower contributed 10.1 million BFOE, or 5 per cent, of the primary energy requirement of the country. The total generation capacity of large hydropower installations is about 2,260 MW, and 5,946 gigawatt-hours of electricity, or 19 per cent of total production, were produced from hydropower in 1994. Installed large-scale hydropower-based generation capacity is expected to increase to 7,065 MW by 2025, and to produce 24,016 gigawatt-hours.

It is also estimated that the country has approximately 30 MW of small hydropower potential. Over 100 small hydropower sites have been identified, and NEA has established a programme to develop those sites.

4. Geothermal power

The Philippines has abundant geothermal reserves with an estimated potential in excess of 8,000 MW, and the country is second only to the United States in utilization of that major energy resource. In 1994, it had 1,149 MW of installed generating capacity that produced 5,667 gigawatt-hours, or 10.9 million BFOE.

Geothermal power is considered to be highly reliable and has low operating costs. It is therefore intended to increase the availability of steam and to develop additional geothermal generation capacity. It is projected that in excess of 72 million BFOE will be displaced through electricity generated from geothermal power in 2025. PNOC is responsible for development of geothermal fields, while NPC develops the power generation facilities.

5. Power subsector

In 1994, there was a total of 9,382 MW of installed generation capacity in the Philippines, which produced 31,288 gigawatt-hours, an increase of 17.7 per cent over 1993 output. Total consumption of electricity was 24,593 gigawatt-hours, with industry being the major end-user (43 per cent) (table XVI.7).

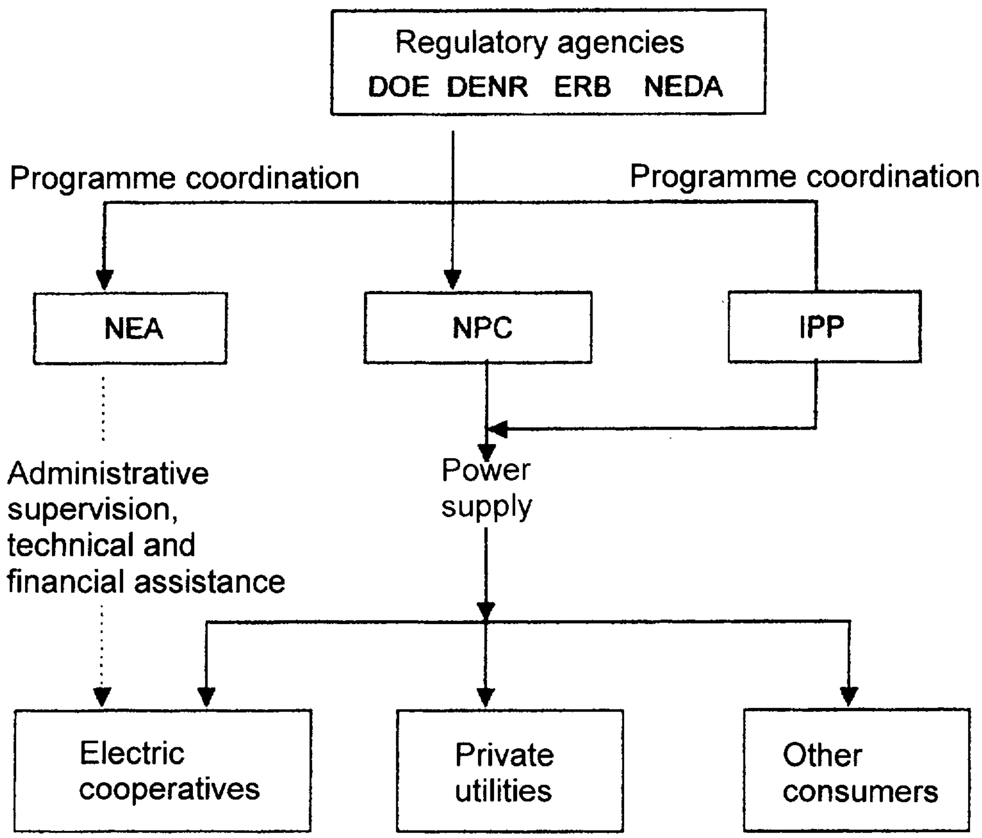
Table XVI.7. Statistics of the basic power sector

Item	1994	1993	Percentage change
Installed capacity, MW	**9,382**	**7,986**	**17.5**
Total generation, Gwh	**31,289**	**26,581**	**17.7**
Oil/diesel	12,437	9,417	32.6
Gas turbine	5,056	4,453	13.5
Hydropower	5,946	5,030	18.2
Geothermal	6,430	5,667	13.5
Coal	1,411	2,014	-29.9
Total consumption	**24,593**	**21,735**	**13.1**
Industrial	10,684	9,426	13.3
Residential	7,282	6,667	9.2
Commercial	5,865	4,838	21.2
Other	762	804	-5.2

Source: Department of Energy, *Philippine Energy Bulletin-January-December 1994*, vol. III (1995).

The relationships of the various players involved in power generation and supply are shown in figure XVI.1. NPC is responsible for generation of power and its distribution to 66-kilovolt-ampere transformers. It acquires power or approves supply contracts for independent power producers involving the sale of electricity to third parties.

Figure XVI.1. Outline relationships for generation and distribution of electricity



NPC sells wholesale power to major industrial end-users and the utilities. Twenty-five utilities distribute power to several urban centres. The largest of these is the Manila Electric Company (MERALCO), which serves Metropolitan Manila and surrounding provinces. RECs provide retail power sales to rural communities. In 1994, there were 118 RECs providing power to 1,326 municipalities and 23,036 Barangays (communes), a total of 3,674 million connections (households). Approximately 50 per cent of households are not connected to the grid.

At present, there are three main grids-for Luzon, the Visayas and Mindanao. In addition, there are separate reticulation systems on the small islands. The major grid is that of Luzon with 6,558 MW of installed capacity, based predominantly on oil and gas and hydropower. There are plans to connect the three main grids to establish a national grid. Negros has already been connected to Cebu and Panay in the Visayas group. Future plans for interconnection include: Leyte and Cebu-1996; Leyte and Luzon- 1997; and Leyte and Mindanao-2000.

The creation of a national grid will allow full development of the geothermal, hydropower and biomass resources in the Visayas and Mindanao regions.

The power development programme included in the draft national energy plan is designed to provide sufficient power to meet economic growth targets. Overall energy sales are forecast to grow at an average of 11.9 per cent up to the year 2005, with the fastest rates in the Visayas (12.3 per cent) and Mindanao (16.3 per cent) [19]. A total of 92,138 MW of new capacity is planned for the period up to 2025, with projects totalling nearly 13,000 MW set for the period up to 2005 (table XVI.8).

Table XVI.8. Summary of planned capacity additions
(MW)

Year	Plant type							
	Hydro-power	Geo-thermal	Coal	Diesel	Gas	OBPP[a]	Non-conven-tional	Total
1996	--	220	--	50	--	--	--	270
1997	--	480	--	100	--	--	--	580
1998	--	80	300	200	--	--	--	580
1999	140	--	1,500	--	--	--	--	1,640
2000	29	160	850	108	700	--	25	1,872
2001	32	--	--	--	1,200	300	--	1,532
2002	368	--	--	--	1,500	250	25	2,143
2003	495	--	--	--	--	300	--	795
2004	600	--	--	--	--	500	25	1,125
2005	584	--	100	--	150	1,400	--	2,234
Total	**2,248**	**940**	**2,750**	**458**	**3,550**	**2,750**	**75**	**12,771**

Source: National Power Corporation, *Power Development Programme 1996-2005*, draft (Manila, 1995).

[a]Other baseload and peaking plants.

The estimated capital cost requirement for the planned generation and transmission projects during the period is in the order of 460 billion pesos, or an average of $2 billion per year. It is expected that the private sector will provide the major proportion of the investment.

Current tariffs applied by NPC are summarized in table XVI.9 [20]. The tariffs vary between end-user and grid. Rates are composed of a basic charge and other billing adjustments. The basic charge consists of demand (fixed cost) and energy (variable cost) charges. The demand charge corresponds to capacity-related costs such as depreciation, operating income, leasing costs and 80 per cent of the operating and maintenance costs. The energy charge corresponds to fuel expenses. The rates are designed to provide a rate of return of 8 to 12 per cent.

Table XVI.9. NPC monthly average energy charge rate
(Pesos per kW-hour)

Grid	1995	1994	Percentage change
Luzon	1.88	1.87	0.53
Visayas	1.99	1.92	3.65
Mindanao	1.34	1.24	8.06
Small islands	1.96[a]	..	..

Source: Department of Energy, *Philippine Energy Bulletin-January-June 1995*, vol. IV (1995).

[a]October 1993.

The rates charged by utilities to the end consumer also vary between customer classification and grid. Rates for Metropolitan Manila as serviced by MERALCO are presented as an example in table XVI.10. However, rates charged to small customers in rural areas by the RECs may be considerably higher, ranging from 4.5 pesos to more than 5 pesos per kWh [13].

Table XVI.10. Manila Electric Company: average monthly price of electricity
(Pesos per kW-hour)

Customer	1995	1994	Percentage change
Residential	3.05	3.05	--
Commercial	3.06	3.03	0.99
Industrial	2.81	2.80	0.36
Others	1.85	1.81	2.21

Source: E. Orencia, Tariff Division, NPC.

The average wholesale price at 1.9 pesos per kWh is equivalent to $0.08 per kWh or 0.0475 pounds (£) per kWh, and the retail price of 3.0 pesos per kWh to $0.12 per kWh and £0.08 per kWh. These prices are high by regional and international standards. Modification of the tariff structure to reflect full marginal costs would further increase electricity selling prices, which could be a serious disincentive to industrial and commercial development within the Philippines. High costs of electricity production do, however, increase the opportunities to develop alternative sources of energy such as biomass, particularly in remote rural areas.

6. Non-conventional energy resources

DOE defines non-conventional energy as biomass, solar, mini-hydropower, small hydropower, wind and ocean energy resources. At present, biomass, particularly wood wastes and bagasse, are responsible for over 99 per cent of non-conventional energy consumption. These resources will be considered in greater detail in later sections of the case study.

The Philippines has been working on alternative energy sources since the 1970s. There have been a number of initiatives to develop non-conventional energy resources, initially in response to the 1973 oil crisis. The two major programmes were the Non-conventional Energy Development Programme and NEA.

Programmes and technologies included geothermal power, wood energy plants, mini-hydropower plants, direct solar and photovoltaic equipment, bioethanol production from sugar cane and molasses and biodiesel based on coconut oil. Energy efficiency and conservation programmes have also been developed.

The various non-conventional energy programmes have not been successful if judged by their contribution to the national energy supply. In 1991, 15.05 million BFOE were produced from these resources, of which at least 97 per cent was from biomass resources (mainly bagasse). The programme has contributed, however, to the development of 14.6 kW of photovoltaics, 259 windmills, 789 biogas systems and hundreds of domestic solar water heaters [21].

DOE, with support from United States aid agencies, has established a wind-resource assessment programme to identify initial commercial sites. NEA has identified 27.8 MW of capacity for mini-hydropower production. The estimated capacity of the ocean thermal resource is in excess of 260 million MW.

In the short term, biomass co-generation projects are considered to be the most appropriate method of mobilizing private resources for the development of non-conventional energy resources. The World Bank [21] considers that projects based on agroprocessing wastes will be attractive to the private sector in the Philippines for a number of reasons, including the following: unreliable power supply and high electricity costs; availability of proven technology; abundant low-cost fuel supplies; ageing equipment in many agroprocessing units; and rural employment generation.

F. Summary of energy development

The Philippines has a rapidly expanding economy, with an increasing need for energy supplies to meet expected demand in all sectors of the community. Although relatively well endowed with indigenous energy resources, these are not sufficient to meet the expanding demand, and the country will therefore remain dependent on imported fossil fuels for the medium term.

DOE has established ambitious targets for supply of a diverse sustainable mix of energy sources to meet expected increases in demand over a 30-year period. It cannot be expected that all the projections will be achieved, but the plan establishes targets and identifies the levels of financial support and infrastructural and institutional reforms needed to meet the targets.

The total financial requirement for the period 1996-2010 is estimated to reach 1,911.4 billion pesos ($75 billion). Of that total, 1,602.3 pesos (83.5 per cent) are to be sourced from the private sector, particularly for the development of electricity generation facilities and energy resources (geothermal energy, oil and gas and coal).

The government has given energy development a high priority, with coordination of policy and implementation being the responsibility of DOE. A number of agencies are charged with implementation of energy activities, from R and D to commercial project development. The Department of Trade and Industry, through BOI, provides incentives for energy project development, particularly of indigenous energy resources, including new and renewable energy technologies.

Biomass, particularly wood wastes and agroprocessing residues, is considered to have the greatest potential to make a significant, cost-effective contribution to the energy plan, particularly in the short to medium term. The potential to develop these resources, with their associated benefits and problems related to their use, will be considered in the remainder of the present study. Constraints on the introduction of appropriate technologies and methods to mobilize funds and resources to accelerate use of biomass as an energy source will also be considered.

XVII. SUPPLY AND CONSUMPTION OF BIOMASS ENERGY

The Philippines is well endowed with biomass resources generated by the extensive agriculture, livestock and forestry industries. In 1989, it was estimated that there were annual reserves of 105 million tonnes of wood equivalent, or 252 million BFOE [22]. Total land area in the Philippines is estimated at 30 million hectares, with 14.1 million hectares of alien and disposable land available for agriculture and 15.9 million hectares designated as forest lands [23].

The Philippines is predominantly an agricultural economy, agriculture being the largest employer and earner of exports income. Current production levels of major crops and livestock are summarized in table XVII.1 [24].

Table XVII.1. Average area and production of selected crops in the Philippines, 1994

Crop or livestock	Area (thousand hectares)	Production (thousand tonnes)	Population (thousand heads)
Rice	3,350	10,150	-
Sugar cane	380	27,800	-
Coconuts	3,000	9,050	-
Maize	3,350	5,400	-
Coffee	141	120	-
Tobacco	34	50	-
Cassava	212	1,850	-
Groundnut	45	35	-
Pigs	-	-	8,227
Cattle	-	-	1,825
Chickens	-	-	68,000
Buffaloes	-	-	2,630
Ducks	-	-	9,000

Source: Food and Agriculture Organization of the United Nations, *Computerized Information Series Production/Forestry Statistics* (Rome, 1995).

The Department of Agriculture has prepared a medium-term development plan for the period 1993-1998, in which key production areas have been identified to focus government support on priority areas and crops. The Government and the private sector are jointly undertaking measures to increase productivity and to attain self-sufficiency in the major food staples. Crops included for promotion include rice, maize, sugar, livestock and tobacco [25].

Primary production in the forestry industry in the Philippines is declining, following a partial, and planned total, ban on logging in traditional forests. However, new areas of plantation forest are being established. The volume of timber available within commercial forests was estimated at 448 million m^3 in 1993 (table XVII.2).

Table XVII.2. Area and estimated volume of timber in commercial forests, 1993

Forest type	Land use (million hectares)	Timber volume (million m^3)
Total forest	5.8	447.9
Dipterocarp	3.9	423.5
Pine	0.2	24.4
Submarginal	0.5	--
Mossy	1.1	--
Mangrove	0.1	--

Source: Asian Development Bank, *Climate Change in Asia: Executive Summary* (Manila,1994).

Although energy crops may be a major future source of biomass fuels, the cost of production and perceived problem of competition with existing food, feed and fibre resources mitigate against their early introduction. This is particularly the case in the Philippines, which is not self-sufficient in the major food and feed crops. However, crop production and the processing of residues provide early opportunities for biomass energy production.

A joint study by the World Bank and the Office of Energy of the Philippines indicated the potential for combined heat and power production using surplus biomass residues from the sugar, coconut and rice industries [21]. These and other biomass resources are considered in further detail in the following sections dealing with: crop production and agroprocessing residue; wood and wood wastes; animal wastes and manure; and biofuels. In each section, the following topics are considered: biomass availability in each main crop or resource; current and potential levels of resource use; technology for conversion of residues to energy; benefits of biomass use; and constraints to increased use.

A summary of current and proposed biomass supply and energy consumption levels, technology availability and linkages and overall benefits of biomass utilization is presented in section E below.

A. Crop production and processing of residues

1. Rice

Residue availability

Rice is the major staple food crop in the Philippines, with production of over 10 million tonnes per year (table XVII.3). Although rice production increased by 2 per cent per annum in the 10 years up to 1990, consumption increased by 3 per cent, leading to increased rice imports. Since 1990, overall production has increased by only 2.7 per cent, even though the national agricultural plan called for annual growth rates of 4 per cent to achieve self-sufficiency.

The 1993-1998 medium-term agricultural plan proposed to concentrate production in key areas in which resources were to be focused to obtain increased yields and to promote the global competitiveness of Philippines rice production. Some 1.2 million hectares for rice were identified as key rice areas for increasing paddy production to 12 million tonnes, with average yields of 5 tonnes per hectare by 1998, up from 3.5 tonnes per hectare in 1993. Yields of 3.03 tonnes per hectare in 1994 suggest that this increase may not be achieved.

Table XVII.3. Production of rice and rice residues in the Philippines (Thousand tonnes per year)

Crop or residue	1980	1985	1990	1991	1992	1993	1994
Rice, paddy	7,646	8,806	9,885	9,673	9,129	9,534	10,150
Rice[a]	4,970	5,724	6,425	6,288	5,934	6,197	6,598
Straw[b]	7,646	8,806	9,885	9,673	9,129	9,534	10,150
Hulls[c]	1,453	1,673	1,878	1,838	1,735	1,811	1,929

Source: Food and Agriculture Organization of the United Nations, *Computerized Information Series Production/Forestry Statistics* (Rome, 1995).

[a]Mission estimate based on a milling recovery of 65 per cent.
[b]Mission estimate based on 1 tonne of straw per tonne of paddy.
[c]Mission estimate based on 200 kg of hull per tonne of paddy.

The National Food Authority (NFA) is responsible for coordination of the production, distribution and marketing of rice and other key food crops in the Philippines. It operates a number of mills and oversees operations in the commercial sector.

Rice production generates two main residues, namely straw produced at harvest and usually left in the field and hull produced in the milling process. Although in terms of volume, straw is the major residue, it is not usually available for use as an energy resource (table XVII.3). Crop production is usually on a small scale, and the straw is produced in dispersed and small volumes mainly left in the field as an organic fertilizer. The hulls, however, are concentrated during the milling process and form a significant biomass resource.

In 1994, NFA estimated that the country had 13,118 mills with a processing capacity of approximately 8,010 tonnes of paddy per hour. NFA operates 61 cono or rubber roll mills with an average output of 3.44 tonnes per hour. The remainder are in the commercial sector, and are small and inefficient with capacities of 1 tonne per hour or less (table XVII.4).

Table XVII.4. Rice-mill operation data, 1995

Mill ownership/type	Number of mills	Total capacity (tonnes per hour)	Average capacity (tonnes per hour)
NFA rice mills[a]	61	177	2.3[b]
Small intake	41	69	1.68
Large intake	19	210	4.74
Buhler mill	1	18	18
Commercial mills	13,057	7,805	0.60[b]
Kiskisan	4,088	1,070	0.26
Cono	2,934	2,680	0.91
Rubber roll	5,934	4,005	0.67
Other	101	50	0.5

Source: D. Areliano, Assistant Director of Business Development and Promotion, National Food Authority.

[a]Cono and rubber roll mills.
[b]Weighted average.

There are three types of rice mill in the Philippines. The kiskisan mill produces a mix of rice hull and bran that is used as an animal feed. The other two mill types - cono and rubber roll mills - separate the hull and bran. The bran is then used as animal feed, and the hull remains as a waste material. It is estimated that 95 per cent of the total rice production is milled in cono and rubber roll mills producing usable hull.

Technology availability

At present, rice hulls are used as an occasional fuel in households and some rural industries. Rice-hull-burning stoves have been developed by DOST [12], and these are marketed commercially in some areas of the country. Rice hulls are used as a fuel for drying paddy, usually in low-technology, hearth-type burners providing underfloor heat to drying tables. Three mills have old co-generation units producing heat and electricity from hull-fired steam boilers. However, these are no longer operative for various technical and environmental reasons.

There are considerable discrepancies in estimates of the current level of rice hull use as either an industrial or household fuel. DOE assumes that 35 per cent of all rice residues (including straw) are consumed as energy. Analysis of the partially completed survey data on the utilization of new sources of energy suggests, however, that only 210,000 tonnes of hull (7 per cent of supply, as estimated by DOE) are used as an industrial and domestic fuel. Discussions with NFA and DOST milling experts suggest that the latter estimates were the most accurate.

Rice hulls with a low moisture content have a relatively high calorific value of 15 gigajoules per tonne, or 2.4 BFOE per tonne. It has, however, a high ash and silica content, overall low density and an erosive nature requiring care in combustion.

It was expected that the heat and power equipment installed at the NFA mills would be re-introduced in 1996. In addition, rice hulls will be increasingly used as a source of heat for crop drying and related rural industries. Equipment is available for this purpose.

A medium- to large-scale husk furnace is being manufactured and distributed by the Pasig Agricultural Development and Industrial Supply Corporation. Of 495 mechanical driers installed in 1991, 41 were fuelled by rice hulls. The team of the United Nations Development Programme responsible for the Financing Energy Services for Small-scale Energy Users (FINESSE) programme estimated the market for rice-hull-fired driers at over 150 units within five years, at an installed value of 188 million pesos (1993 value). The payback period for such installations was estimated at four to five years, and the fuel replaced was industrial fuel oil [26].

DOST has developed a small-scale rice-hull gasifier and demonstrated the technology for a number of drying operations [11]. The equipment is suitable for small rice mills (0.5 to 1 tonne per hour). This and other low-technology hearth equipment and simple heat exchangers are suitable for drying operations, and could significantly increase residue utilization. DOE estimates that the market potential is in excess of 100 paddy driers.

The World Bank and EC/ASEAN COGEN have also analysed various options for both heat and power co-generation. The potential use would be for the larger mills (over 1 tonne/hour) to produce electricity for their own use, and thus replace power purchased from the national grid or self-generated with diesel equipment. The World Bank evaluated a range of scenarios involving units of 75 kW to 3 MW. Their economic analysis suggested that projects above 350 kW were commercially viable on the assumption that current electricity costs were in excess of 2.5 pesos per kW-hour [21]. They concluded that there was a realistic potential of up to 40 MW of installed capacity.

Similar results were achieved by EC/ASEAN COGEN, which proposed two rice-hull-based co-generation projects of 400 kW and 800 kW for funding in 1993/94. Approximate capital costs were estimated at $1,900 per installed kW.

Two further rice-hull-based power projects are under consideration in the Philippines. A United States-based company, has proposed a 35 MW project for Northern Luzon. The company intends to acquire all available rice hull from an 80-kilometre radius. It has received conditional accreditation from EIAB, and has 12 months to finalize the project. PNOC is evaluating the potential for commercial power production from a cluster of mills. Details on this project were not available, but it is considered to be a 3-4-MW project similar to those proposed under the Energy Sector Management Assistance Programme.

Projected residue utilization

DOE has prepared an estimate of rice residue availability and consumption for the period 1996-2025, on the basis of expected increases in paddy production (average growth rate of 2 per cent per annum) and an increased use of all residues from 35 per cent in 1996 to 57 per cent in 2025. This is summarized in table XVII.5. Data are presented in terms of tonnes of residue availability and millions of BFOE energy availability and consumption.

A comparative analysis of rice residue availability and use was prepared by the UNIDO mission, and the results are also presented in Table XVII.5. Production of paddy is estimated to increase at 2 per cent per annum. The proportion of dry residue per tonne of paddy were calculated as 200 kg of rice hulls (2.4 BFOE per tonne of hulls) and 1 tonne of straw (2.4 BFOE per tonne of straw) [5].

UNIDO estimated 0.5 million BFOE in 1996 compared to 2.5 million BFOE by DOE. DOE estimates rise to 15.9 million BFOE by the end of the period, double the UNIDO estimate, which is based on 40 per cent utilization of the available rice hull and 8 per cent of the straw.

Economic and environmental benefits

The value of a BFOE was calculated as $18.96 in 1995 dollars. On the basis of this value, foreign exchange savings through displacement of imported fossil fuels can be estimated, according to their primary energy content. The data in table XVII.5 indicated savings of between $9 million and $44 million in 1996, rising to between $140 and $281 million dollars (in terms of real 1995 dollars) in 2025.

The Asian Development Bank estimated that combustion of 1 BFOE irreversibly releases 484 kg of carbon dioxide [27, 28]. The use of rice residues is assumed to displace combustion of fuel oil and diesel. Therefore, as rice is produced on a sustainable basis, this is equivalent to a net reduction of carbon dioxide emissions of between 242,000 and 1.2 million tonnes in 1996, and between 3.8 million and 7.7 million tonnes in 2025, for the UNIDO and DOE projections, respectively.

Constraints to development

It was considered in discussion with DOE, DOST, NFA and EC/ASEAN COGEN that current obstacles to the introduction of new biomass technologies are lack of awareness of the various technology options and their financial viability. There is a need to demonstrate the use of the biomass energy conversion technologies and to confirm the rate of capital payback. If the pre-feasibility analyses of the World Bank and EC/ASEAN COGEN are accurate, then the current costs of diesel

Table XVII.5. Projections of production and consumption of rice residues

Projections			1996	2000	2005	2010	2015	2020	2025
DOE									
Crop production	Paddy	(1 000 tonnes)	10,970	12,843	15,624	19,008	23,118	28,135	34,239
Residue production	Straw	(1 000 tonnes)	1,975	2,312	2,812	3,422	4,162	5,065	6,164
	Hull	(1 000 tonnes)	2,194	2,569	3,125	3,802	4,624	5,627	6,848
	Total	(1 000 tonnes)	4,169	4,881	5,937	7,224	8,786	10,692	13,012
Energy supply	Straw	(million BFOE)	2	3	4	4	5	6	8
	Hull	(million BFOE)	5	6	7	8	10	12	15
	Total	(million BFOE)	7	9	11	13	15	19	23
Total energy consumption		(million BFOE)	3	3	5	7	9	12	16
DOE utilization factor		(per cent of supply)	43	33	45	54	60	63	70
UNIDO mission									
Crop production	Paddy	(1 000 tonnes)	11,510	12,841	14,177	15,653	17,282	19,080	21,066
Residue production	Straw	(1 000 tonnes)	11,510	12,841	14,177	15,653	17,282	19,080	21,066
	Hull	(1 000 tonnes)	2,187	2,440	2,694	2,974	3,284	3,625	4,003
Total residues	Total	(1 000 tonnes)	13,697	15,281	16,871	18,627	20,566	22,705	25,069
Energy supply	Straw	(million BFOE)	28	31	34	38	41	46	51
	Hull	(million BFOE)	5	6	6	7	8	9	10
	Total	(million BFOE)	33	37	40	45	49	55	61
Energy consumption	Straw	(million BFOE)	0	2	2	2	3	3	4
	Hull	(million BFOE)	1	1	1	2	2	3	4
	Total	(million BFOE)	1	3	3	4	5	6	8
UNIDO energy	Straw	(percentage)	0	6	6	5	7	7	8
Utilization factor	Hull	(percentage)	20	16	16	20	25	33	40

Source: L. D. Cabanes, "Napocor sets Lenient Rules for Non-conventional Energy", *Manila Bulletin*, 13 September 1995 and UNIDO mission estimates.

generation and retail prices of electricity from RECs would make conversion to biomass fuels attractive for drying of paddy and production of electricity for their own use.

The large and expanding resource base in the rice sector coupled with Department of Agriculture plans to concentrate production in key areas, presumably with rationalization of milling facilities, will intensify use of rice residues.

2. *Sugar cane*

Residue availability

The sugar industry has a long history in the Philippines, but it suffered a serious decline from the mid 1970s to the end of 1980s because of a mixture of mismanagement and loss of export markets. Investor confidence has returned in recent years, and production levels have stabilized at around 28 million tonnes of cane and 2 million tonnes of sugar (table XVII.6).

The Philippines Sugar Millers Association advises that there are 39 mills, of which 37 are operative (table XVII.7). The bulk of the mills are situated in Negros, which provides approximately 56 per cent of the national sugar consumption. The Philippines Sugar Millers Association considers that the growing domestic market and the United States quota will result in continued growth in sugar production at between 2 and 4 per cent per annum. A new mill is currently under consideration for the Mindanao region. Additional capacity increases are expected in the short term through rehabilitation of existing mills.

Mills generally do not have large estates, and acquire cane from a number of smallholder producers. The farmer delivers cane to the mill, where it is weighed and the sugar content analysed. The value of the recovered sugar is then shared between the mill (35 per cent) and the producer. The majority of mills process cane to raw sugar, which is refined to white sugar at mills with refining capacity. There are 15 refiners. One mill has a distillery producing potable alcohol.

Residues from sugar-cane production include field cane trash, bagasse and molasses. Sugar-rich molasses can be fermented to produce fuel ethanol for blending with gasoline. Molasses, however, has a value as an animal feed or for production of rum, and the relatively low value of gasoline does not make this a commercially viable operation.

Sugar-cane production generates two main residues - bagasse and field trash. The UNIDO mission estimated that 150 kg of dry bagasse and 250 kg of field trash are produced per tonne of cane. The calorific value of bagasse is assumed to be 2.72 BFOE per tonne of bagasse, and that of field trash 1.92 BFOE per tonne.

An estimate of the availability of bagasse and field trash is summarized in table XII.6, with World Bank estimates for individual mills in table XVII.7. In 1994, cane production was 28 million tonnes of cane producing over 4 million tonnes of dry bagasse with an energy content of approximately 11 million of BFOE.

Field trash represents an even greater energy resource, with nearly 7 million tonnes available in 1994, equivalent to 13 million BFOE. Unlike bagasse, which is concentrated in the sugar mill, the trash requires collection and separate handling. With the current share-cropping arrangement for the supply of cane in the Philippines, this would be problematic. As the trash is collected at one mill and given a viable market for surplus energy, similar arrangements could be made elsewhere.

Table XVII.6. Production of sugar in the Philippines
(Thousand tonnes per year)

Item	1980	1985	1990	1991	1992	1993	1994
Sugar cane	30,920	23,133	25,930	25,380	29,400	27,780	27,800
Sugar centrifugal	2,343	1,731	1,810	1,736	2,061	2,058	1,860
Sugar non-centrifugal	26	18	90	90	90	90	90
Sugar-cane trash	7,730	5,783	6,483	6,345	7,350	6,945	6,950
Sugar-cane bagasse	4,638	3,470	3,890	3,807	4,410	4,167	4,170

Source: Food and Agriculture Organization of the United Nations, *Computerized Information Series Production/Forestry Statistics* (Rome, 1995).

Table XVII.7. Waste production in sugar mills, 1991-1992

Mills	Gross cane throughput (million tonnes)	Bagasse (million tonnes)	Field trash (million tonnes)
Luzon	**4,720,685**	**1,213,504**	**663,224**
Carsumco	56,548	16,236	18,048
Hind	28,401	8,526	42,368
Paniqui	137,714	44,479	..
Tarlac	1,142,634	321,405	92,176
Arcam	340,675	89,866	52,952
Pasudesco	540,679	129,072	107,728
Canlubang	566,953	15,706	98,488
Don Pedro	1,329,068	384,497	96,912
Batangas	406,890	154,944	124,952
Bisudesco	171,123	48,773	29,600
East Visayas	**1,439,992**	**504,962**	**192,360**
Bogo-Medellin	502,454	118,835	83,272
Durano	205,233	58,286	..
Hideco	502,804	135,868	109,088
Ormoc	229,501	58,522	..
Panay	**1,828,954**	**496,791**	**222,656**
Pilar	389,157	106,582	34,856
Asturias	270,247	77,614	33,568
Passi	711,581	186,264	154,232
G. Frontier	443,027	130,114	..
Barotac	14,942	4,388	..
Negros	**13,502,507**	**3,772,046**	**1,577,472**
Azucar	297,182	85,685	170,408
Daesumico	114,923	34,167	..
First Farmers	918,170	25,360	..
Hawaiian-Phil	1,108,872	270,453	89,512
Aidsisa	744,872	196,020	..
Vicmico	2,467,952	881,946	210,152
Lopez	1,031,539	289,243	87,392
Sagay	633,106	183,593	111,216
Danao	229,478	64,971	..
San Carlos	348,605	95,587	67,048
Ma-ao	399,081	99,992	81,344
La Carlota	1,433,852	405,636	138,624
Biscom	1,136,075	324,058	218,704
Conedco	594,871	169,479	85,160
Dacongcogon	209,481	59,485	69,040
Ursumco	672,528	232,158	184,968
Bias	756,864	237,308	..
H. Teves	405,056	116,905	63,904
Mindanao	**1,323,618**	**429,653**	**310,016**
Busco	1,162,732	375,933	249,104
Dasuceco	160,886	53,720	60,912
Nocosii	..	..	..
Philippines	**22,815,755**	**5,920,165**	**2,965,728**

Source: World Bank, *Philippines: Commercial Potential for Power Production from Agricultural Residues*, report No. 157/93 (Washington, D.C.,1993).

Technology availability

There have been three recent, inter-related studies of potential for energy production from the Philippines sugar industry [21, 29, 30]. Each study has concluded that there is considerable potential for the sugar industry to generate surplus power from increased efficiency of power production and utilization.

The EDUFI study considered 17 mills in detail. As of the end of 1993, the boiler units of these mills had an average age of 39 years. Thermal efficiencies ranged from 10 to 80 per cent. The systems were operated effectively as bagasse incinerators; however, the mills still generate excess bagasse at the end of the season.

There are opportunities to improve the efficiency of energy production through either refurbishment of current systems or replacement of boilers to use either low-to-medium-efficiency or high-efficiency high-pressure boilers. There are also considerable opportunities to optimize operations and to introduce correctly sized electric motors to reduce consumption of steam electric power.

The World Bank concluded that the sugar industry could conservatively contribute an additional 60-90 MW of installed capacity to the grid, as well as meeting its own heat and power requirements. EDUFI computed the total installed capacity of the 17 mills at 243 MW, with 81 to 110 MW available for export to the grid. This was equivalent to between 278 and to 787 gigawatt-hours, depending on the length of the operating season. The use of cane trash and mixing of local, low-grade coal were two options considered for extension of the electricity generation period.

The total equipment investment costs for these developments were estimated at from $75 million to $112 million. Prefeasibility analysis was completed for various scenarios assuming a purchase price of 1.80 pesos per kWh. In the worst case, 7 mills had payback periods of less than 3 years, and in the most attractive option (operating year round), 12 mills had similar payback periods. One mill (BUSCO) in Mindanao is already selling surplus power to the grid, and two others are seeking accreditation through EIAB.

Projected residue utilization

Comparisons of various projected levels of sugar-cane residue use during the period 1996-2025 have been prepared, and are summarized in table XVII.8. DOE projected increases in bagasse supply at an average of 4 per cent per annum throughout the period. Utilization of the available residues was estimated to be 53.5 per cent in 1996, rising to 85 per cent in 2025. The UNIDO estimate assumed annual growth rates of 2 per cent for sugar cane production throughout the same period and utilization of 55.1 per cent of bagasse and 5 per cent of cane trash in 1996. This rises to 98 per cent of bagasse in 2025 and 22 per cent of available cane trash.

It was noted that irrespective of the variations in the base assumptions of residue supply, utilization rates and energy content, the overall energy consumption levels are comparable for both projections throughout the period analysed (table XVII.8).

Economic and environmental benefits

A total of 6 million to 7 million BFOE of sugar-cane residues were projected to be consumed in 1996. On the basis of earlier assumptions, this is equivalent to a foreign exchange saving of $106 million to $127 million, through reductions in fuel imports. Such imports are projected to increase from

Table XVII.8. Projected production and consumption of sugar-cane residues

Projections			1996	2000	2005	2010	2015	2020	2025
DOE									
Crop production	Cane	(1 000 tonnes)	26 157	30 607	30,607	45,316	55,122	67,070	81,588
Residue Production	Bagasse	(1 000 tonnes)	6 638	7 768	7,768	11,501	13,989	17,021	20,706
	Trash	(1 000 tonnes)	879	1 029	1,029	1,523	1,853	2,254	2,742
	Total	(1 000 tonnes)	7 517	8 797	8,797	13,024	15,842	19,275	23,448
Energy supply	Bagasse	(1 000 tonnes)	10	12	12	17	21	25	31
	Trash	(1 000 tonnes)	1	1	1	2	2	3	3
	Total	(1 000 tonnes)	11	13	13	19	23	28	34
Energy consumption		(million BFOE)	6	7	7	13	17	22	29
DOE utilization factor		(percentage)	54	54	58	69	74	79	85
UNIDO mission									
Crop production	Cane	(1 000 tonnes)	28,923	31,307	34,566	38,163	42,136	46,521	51,363
Residue production	Bagasse	(1 000 tonnes)	4,338	4,696	5,185	5,725	6,320	6,978	7,704
	Trash	(1 000 tonnes)	7,231	7,827	8,641	9,541	10,534	11,630	12,841
	Total	(1 000 tonnes)	11,569	12,523	13,826	15,266	16,854	18,608	20,545
Energy supply	Bagasse	(million BFOE)	12	13	14	16	17	19	21
	Trash	(million BFOE)	14	15	17	18	20	22	25
	Total	(million BFOE)	26	28	31	34	37	41	46
Energy consumption	Bagasse	(million BFOE)	6	8	9	11	14	17	20
	Trash	(million BFOE)	1	1	1	2	3	4	5
	Total	(million BFOE)	7	9	10	13	17	21	26
UNIDO utilization factor	Bagasse	(percentage)	50	61	64	73	70	89	95
	Trash	(percentage)	7	6	6	10	11	18	20

26 million to 29 million BFOE, equivalent to a foreign exchange saving of $545 million to $512 million in 2025.

The sugar-cane industry offers the greatest commercial opportunity to supply surplus electricity to the national grid, and thus displace planned new capacity based on imported fossil fuels. Accelerated development of power sales from the 15 largest mills or for mills clustered in Negros Occidental could achieve such a result in the next 5 to 10 years, given appropriate government support.

On the assumption that combustion of sugar-cane residues displaces fossil fuels, a maximum net reduction in carbon dioxide emissions of 2.9 million tonnes could be achieved in 1996 and 14 million tonnes in 2025.

Constraints to development

Discussions involving the Philippines Sugar Millers Association, EDUFI and EC/ASEAN COGEN suggested that there are no significant technical constraints to increased use of bagasse with sales of surplus power to the grid. A number of mills have already established or identified joint venture and technology partners for independent power production projects.

Financing would not be an immediate limiting factor for early project development. Concessional sources of finance, however, particularly for feasibility studies, would be advantageous for accelerated programme development through support to mills in poorer financial condition.

A major constraint is considered to be the delay in preparing a standard power purchase agreement between NPC and the sugar industry. Such an agreement should establish a purchase price for the electricity that fully reflects the benefits of avoided cost for NPC through the scale and timeliness of new generating capacity additions by sugar mills. Negotiations are in progress with NPC to facilitate preparation of such an agreement.

An additional barrier to power project development would be the current arrangements for cane sharing. The sugar industry would have to consider establishment of new ventures to acquire the bagasse and to sell heat and power back to the mill and the grid. These additional income streams could then be separately identified and shared between the principals. Such an arrangement would also allow maximization of BOI incentives to the new power company.

It is also considered that an industry-wide promotion and training programme to highlight the benefits of upgrading the technical capabilities of existing mills would be advantageous to long-term industry development.

3. *Coconut industry*

Residue availability

Although palm oil production is rapidly expanding, with a 450 per cent increase from 1975 and a doubling since 1985, it is still only a small fraction of the level of production and importance of coconut in the economy. The palm oil industry is usually self-sufficient in energy, producing heat and steam from combustion of fibrous residues of the oil extraction process. The mission did not evaluate the level of biomass utilization and availability of palm-oil-industry residues in the Philippines. This may be of interest for later analysis if the industry expands.

The Philippines is one of the world's largest producers of coconut (table XVII.9). Following a period of decline, copra production in 1990 was estimated at approximately 2 million tonnes

Table XVII.9. Production of selected oil-seed crops in the Philippines
(Thousand tonnes per year)

Crop	1975	1980	1985	1990	1991	1992	1993	1994
Coconuts	9,219	9,141	8,600	11,023	8,638	9,384	9,063	9,050
Copra	2,053	1,860	1,459	2,383	1,883	1,890	1,900	1,780
Shell	2,074	2,057	1,935	2,480	1,944	2,111	2,039	2,036
Husk	4,563	4,525	4,257	5,456	4,276	4,645	4,486	4,480
Palm oil	11.0	12.5	34	46	54	54	55	61
Palm kernels	2.0	2.5	9	11.4	14	15	16	16

Source: Food and Agriculture Organization of the United Nations, *Computerized Information Series Production/Forestry Statistics* (Rome, 1995) and UNIDO mission estimates.

(table XVII.10), and has remained relatively constant since that time. In excess of 3 million hectares are planted with coconut, and there are 2 million coconut producers. The Philippines Coconut Authority considers that some 20 million people depend on the coconut industry for their livelihood [31, 32].

Table XVII.10. Coconut production by region in the Philippines, 1990
(Tonnes)

Region number	Coconut production[a]	Copra production
I	8,491	1,350
II	3,377	537
III	--	--
IV	1,552,914	293,590
V	1,899,765	302,063
VI	266,107	42,311
VII	423,176	67,285
VIII	1,297,545	206,310
IX	1,244,445	197,867
X	1,333,451	212,019
XI	2,172,211	345,382
XII	978,464	155,576
ARMM	1,130,319	179,721
Philippines	**12,310,265**	**2,004,011**

Source: World Bank, Philippines: Commercial Potential for Power Production from Agricultural Residues, report No. 157/93 (Washington, D.C., 1993).

[a]Whole nut minus husk.

There are slight discrepancies between sources of production statistics. For consistency, the mission used FAO production data in preparing energy supply and consumption data.

There were 180 coconut industries operating in the Philippines [33], consisting of 100 oil mills (table XVII.11), 63 oil refineries (table XVII.12), 11 desiccated-coconut plants (table XVII.13) and 6 producers of activated carbon (table XVII.14).

The Philippines Coconut Authority and the United Coconut Associations of the Philippines are responsible for coordination and monitoring of coconut production and processing activities.

The coconut produces a number of residues suitable for energy production, including:

(a) The husk, which is the dry fibrous outer covering of the fruit (33 per cent of the harvested crop);

(b) The shell, which is the thin hard portion between the husk and the meat (15 per cent of husked nuts);

(c) Fibrous residues (following oil extraction);

(d) Coir dust (following production of coir matting from coconut husk).

Table XVII.11. Regional distribution of coconut-oil mills in the Philippines, 1993

Area or region	Number of mills	Copra crushing capacity (Thousand tonnes per year)
Metropolitan Manila	16	785
Laguna/Quezon (southern Tagalog)	28	789
Bicol	5	491
Visayas (eastern and western)	21	667
Mindanao (north-east and south-east)	2	2,283
Other	2	6
Philippines	**74**	**5,021**

Source: EC/ASEAN COGEN, *Biomass Resources in the Wood and Agro-Industries in ASEAN*, vol. 5, Coconut Sector (1994).

Table XVII.12. Regional distribution of coconut-oil refineries, 1993

Area or region	Number of mills	Maximum production capacity (Thousand tonnes per year)
Metropolitan Manila	21	402
Laguna/Quezon (southern Tagalog)	15	451
Bicol	1	5
Visayas (eastern and western)	11	181
Mindanao (north-east and south-east)	13	343
Other	2	3
Philippines	**63**	**1,385**

Source: EC/ASEAN COGEN, *Biomass Resources in the Wood and Agro-Industries in ASEAN*, vol. 5, Coconut Sector (1994).

Table XVII.13. Regional distribution of desiccated coconut plants, 1993

Area or region	Number of mills	Production capacity (Thousand tonnes per year)
Metropolitan Manila	1	3
Laguna/Quezon (southern Tagalog)	7	123
Bicol	--	--
Visayas (eastern and western)	--	--
Mindanao (north-east and south-east)	3	32
Other	--	--
Philippines	**11**	**158**

Source: EC/ASEAN COGEN, *Biomass Resources in the Wood and Agro-Industries in ASEAN*, vol. 5, Coconut Sector (1994).

Table XVII.14. Regional distribution of activated carbon producers, 1993

Area or region	Number of mills	Production capacity (Thousand tonnes per year)
Metropolitan Manila	--	--
Laguna/Quezon (southern Tagalog)	2	10
Bicol	-	-
Visayas (eastern and western)	-	-
Mindanao (north-east and south-east)	4	22
Other	-	-
Philippines	**6**	**32**

Source: EC/ASEAN COGEN, *Biomass Resources in the Wood and Agro-Industries in ASEAN*, vol. 5, Coconut Sector (1994).

There are approximately 1.2 tonnes of shell and 2 tonnes of husk produced for each tonne of copra. The problem, however, is that the bulk of the resources (80-85 per cent) are left at the point of harvest i.e. in the field. Approximately 5 per cent of the husks are used for copra drying. A small proportion of the husk is used for the coir fibre industry, generating coir dust as a potential biomass fuel source. The Philippines Coconut Authority indicates that there are 20 decortication units producing an average of 2 tonnes of fibre per day and 4 tonnes of dust, which according to DOST, is a suitable fuel for its agrowaste gasification unit. No formal statistics on the collection of coconut fronds are available, and the level of the resource can only be estimated. However, fronds provide a useful domestic fuel, and are used at village level as an additional fuel for copra drying. Coconut shells are generally concentrated in the coconut-processing industries. The Philippines Coconut Authority estimated that 1.87 million tonnes of shell are available, of which 860,000 tonnes are utilized, the remainder (1.1 million tonnes) being available for use as an energy resource. The World Bank considered 37 per cent of the shells was unutilized. At present, only a small proportion of shells is used in drying the copra (5-15 per cent). However, most is used for production of charcoal, which is then consumed as a domestic fuel, or is converted into a high-value activated charcoal for export. Charcoal is often obtained-inefficiently-by artisanal production at the village level, the result being a low-quality domestic fuel. The potential exists to upgrade the industry and utilize the waste heat of the production process. Approximately 4 tonnes of coconut shell are required to produce 1 tonne of charcoal, with the resultant loss of 63 per cent of the available energy.

Technology availability

Technologies exist for improved carbonization of coconut shell, with associated utilization of the waste energy for process heat and possibly electricity production. The Natural Resource Institute of the United Kingdom of Great Britain and Northern Ireland and a Philippines entrepreneur have developed and demonstrated appropriate technology for waste heat recovery from biomass carbonization. The Philippines Coconut Authority has established a pilot plant to demonstrate the suitability of the Philippines technology for small-scale electricity production. The scale would be suitable for input of 8 tonnes per day of raw shells, requiring 3,000 hectares of coconut plantations.

Projected residue utilization

Projections of the utilization of coconut residues during the period 1996-2025, presented in table XVII.15, were prepared by DOE and the UNIDO mission for comparison.

Table XVII.15. Projected coconut residue availability and consumption

Projections			1996	2000	2005	2010	2015	2020	2025
Department of Energy									
Crop production	Whole Nut	(1 000 tonnes)	12,872	13,937	15,386	16,988	18,757	20,707	22,860
Residue production	Total	(1 000 tonnes)	12,028	13,023	14,377	15,874	17,527	19,350	21,361
Energy supply	Total	(million BFOE)	18	20	22	24	27	30	33
Energy consumption	Total	(million BFOE)	6	7	10	12	16	19	23
DOE utilization factor		(million BFOE)	33	35	45	50	59	63	70
UNIDO									
Crop production	Whole nut	(1 000 tonnes)	13,985	14,843	15,991	17,226	18,558	19,992	21,537
Residue production	Shell	(1 000 tonnes)	2,098	2,227	2,399	2,584	2,784	2,999	3,231
	Husks	(1 000 tonnes)	4,615	4,898	5,277	5,685	6,124	6,597	7,107
	Fronds	(1 000 tonnes)	4,662	4,946	5,330	5,742	6,186	6,664	7,179
	Total	(1 000 tonnes)	11,375	12,071	13,006	14,011	15,094	12,260	17,517
Energy supply	Shell	(million BFOE)	5	5	6	6	7	7	8
	Husks	(million BFOE)	--	9	10	11	12	13	14
	Fronds	(million BFOE)	4	5	5	5	6	6	7
	Total	(million BFOE)	18	19	21	22	24	25	29
Energy consumption	Shell	(million BFOE)	1	1	2	2	3	4	6
	Husks	(million BFOE)	--	1	1	1	1	1	1
	Fronds	(million BFOE)	1	1	1	1	1	1	1
	Total	(million BFOE)	2	3	4	4	5	6	8
Utilization factor	Shell	(percentage)	20	20	33	33	43	57	75
	Husks	(percentage)	--	11	10	9	8	8	7
	Fronds	(percentage)	25	20	20	20	16	26	14

Source: Department of Energy, *Philippines Energy Plan 1996-2025* (Manila, 1995) and UNIDO mission estimates.

The DOE energy consumption levels are based on utilization of 31 per cent of all residues in 1996, rising to 64 per cent in 2025. The UNIDO estimates lower current use of all residues, which stood at 15 per cent of shells, 5 per cent of husks and 20 per cent of fronds (domestic fuels) in 1996. Shell utilization is expected to increase to 71 per cent in 2025, reflecting improved waste-heat recovery technology in charcoal manufacture. Use of husk will remain low at 9 per cent in 2025, because of the difficulty of collection. Increased production of coir products will, however, allow heat and power production from coir dust. The proportion of energy production from fronds will remain unchanged throughout the period. Residue utilization rates are shown in table XVII.15.

DOE estimated that 6 million BFOE would be used in 1996, compared with 2 million BFOE predicted by the UNIDO mission. This discrepancy remains throughout the period, because of the lower utilization rate assumed in the UNIDO analysis. The UNIDO mission estimate in 2025 is 8 million BFOE, whereas DOE estimates 23 million BFOE.

The Philippines Coconut Authority is proposing significant changes to the coconut industry over the medium term. It would like to see the development of centralized coconut processing facilities built around nuclear coconut estates. These facilities would process the whole nut. The World Bank concluded that it would be possible to establish co-generation facilities within such estates. The minimum projected scale was 7,500 hectares of coconut estates or coconut-oil mills producing 7,500 tonnes per year. These scenarios produced attractive financial returns, with the potential for 20 MW of installed capacity in the medium term.

Economic and environmental benefits

The use of coconut residues as an energy resource could displace from 3 million to 6 million BFOE of imported fuels in 1996. At a value of $18.96 per BFOE (energy equivalence), this represents a potential saving of foreign exchange equivalent to between $40 million and $114 million in 1996. With energy consumption of 8 million to 23 million BFOE, the potential foreign-exchange saving increases to between $153 million and $436 million in 2025.

If the fuel displaced by the use of coconut residues is fossil-based, then there were opportunities to reduce net carbon-dioxide emissions by a maximum of 2.9 million tonnes in 1996, rising to 11 million tonnes in 2025.

Constraints to development

DOE still considers the potential of coconut residues for energy production to be high, but requires further commercial evaluation by the private sector. Constraints to increased implementation of coconut residues as an energy resource are considered to be the low concentration of residues, lack of awareness of technology availability and the need to demonstrate commercially and technically viable technologies. The coconut industry, although large, is generally considered to be cash-poor; new investment is therefore likely to require the availability of concessional sources of finance.

4. *Other crops*

The potential for utilization of residues from other crops has not been estimated in the present report. There will be a number of niche opportunities to use the residues of crops such as groundnut and cashew shells, coffee and cocoa husks, cassava stems and starch wastes. However, apart from anecdotal comments on the use of coffee hulls for process heat by Nestle, no details on these matters were obtained.

B. Wood and wood wastes

1. Resource availability

Fuelwood is the major source of energy in the Philippines, being the predominant domestic cooking and heating fuel. In addition, fuelwood and its substitutes provide a significant proportion of energy for rural industries.

Various estimates of fuelwood availability and use have been made for both domestic and industrial use [22, 34]. The RegionalWood Energy Development Programme also maintains regular surveys of wood and wood wastes at the local level [35]. It is generally considered that there are no significant pressures on fuelwood supply for either domestic or industrial use.

The Philippines is endowed with a rich biomass resource base, particularly in relation to available forest resources. Although designated forest lands comprise 15.88 million hectares, only 5.8 million hectares are covered with forest. There is an estimated reserve of 448 million m^3 of timber in the commercial forest area [23].

The Philippine timber industry is in a period of decline under an increasingly stringent forest licensing regime and following introduction of a partial ban on logging from native forests. It is expected that a total ban will be placed on logging from traditional forests in the near future. Future logging will have to be from commercial forestry plantations. Although, there is some discrepancy between statistics on current levels of production in the Philippines, production of roundwood and saw-log has declined since 1980 (table XVII.16).

Table XVII.16. Timber production in the Philippines
(Thousand m^3 per year)

Production estimates	1980	1985	1990	1991	1992	1993
FAO						
Industrial roundwood	8,984	5,713	4,993	4,466	3,898	3,594
Sawlog and veneer logs (not conditioned)	6,212	3,124	2,155	1,558	798	685
Fuelwood	26,360	29,688	33,448	34,213	35,254	35,980
Forest Management Bureau (FMB)						
Roundwood	6,462	3,914	2,596	2,141	1,757	1,152
Sawlogs	5,978	3,185	2,156	1,561	800	685
Lumber	1,529	10,62	841	726	647	440

Sources: Forest Management Bureau, Department of Environment and Natural Resources, 1993 *Philippine Forestry Statistics* (Quezon City, 1994). Food and Agriculture Organization of the United Nations, *Computerized Information Series Production/Forestry Statistics* (Rome, 1995).

Sources of fuelwood from forest lands include logging residues, timber wastes and wastes from sawmill and woodworking operations, as well as wood harvested specifically for fuel. It is generally estimated that forest residues represent a minimum of 67 per cent of roundwood production. An equivalent level of waste is produced as sawdust and offcuts in the sawmill and woodworking industries. Levels of residue availability from forest lands are estimated in Table XVII.17. FAO estimates of harvested fuelwood were equivalent to 50 million BFOE in 1993.

Table XVII.17. Estimates of wood and residue production in the Philippines

Source of estimates	1980	1985	1990	1991	1992	1993
A. Wood and residue production (thousand tonnes)						
FAO						
Forest residues	3,287	2,090	1,827	1,634	1,426	1,315
Sawdust/wood wastes	2,272	1,143	788	570	292	251
Fao fuelwood	4,229	16,190	18,248	18,652	19,052	19,449
FMB						
Forest residues	2,364	1,432	950	783	643	421
Sawdust/wood wastes	3,264	1,739	1,177	852	437	374
B. Residue production (million BFOE)[a]						
UNIDO						
Forest residues	7.9	5.0	4.4	3.9	3.4	3.2
Sawdust/wood wastes	5.4	2.7	1.8	1.4	0.7	0.6
Fuelwood	34.2	38.9	43.7	44.7	45.7	46.7
UNIDO						
Forest residues	5.7	3.4	2.3	1.9	1.5	1.0
Sawdust/wood wastes	7.8	4.1	2.8	2.1	1.1	0.9

[a]UNIDO mission estimates for residues based on table XVII.28, assuming that there are 546 kg of wood per m^3 of wood and 670 kg of residues per tonne of wood harvested, and 2.4 BFOE per tonne of residue.

The number of timber licenses were reduced from 97, covering 3.8 million hectares and an allowable annual cut of 5 million m^3 in 1990, to 54 licenses in 1993 for an annual cut of 1.4 million m^3. It is estimated that there are 95 operative sawmills in the Philippines, with a total daily capacity of 4,184 m3 [23]. The majority of sawmills are operating well below capacity. It is estimated that in 1993 approximately 251,000 tonnes of sawdust residue were produced. DOST estimated potential sawdust production of 748,209 tonnes in 1991 [13].

Fuelwood is also produced from designated agricultural lands, either from small dedicated woodlots or informal harvesting from timber growing on farmland. Estimates in excess of 66 million tonnes of wood available from these sources were made by the Energy Sector Management Assistance Programme and DOE [22].

It is considered that there is no shortage in the fuelwood supply in the Philippines.

2. *Projected fuelwood supply and utilization*

Levels of wood and wood-waste utilization have been estimated by DOE on the basis of the household survey of the Energy Sector Management Assistance Programme [22] and the Forest Management Bureau survey of fuelwood use in business establishments [34] (table XVII.18). In 1989/90, a total of 25 million tonnes of fuelwood (including charcoal) were used in households and 4.4 million tonnes in industry. Approximately 9 million tonnes of crop residues were also used as energy resources in both sectors.

Table XVII.18. Estimated use of wood and fuelwood substitutes, 1989-1990

End-use	Volume (million tonnes)	Energy content (million BFOE)
Industry total	7.9	**18.7**
Wood/wood wastes	**4.4**	**10.4**
Forest residues	2.7	6.5
Timber industry residues	1.4	3.2
Other	0.3	0.7
Wood substitutes	**3.5**	**8.3**
Bagasse/rice	2.7	6.4
Coconut residues	0.4	1.0
Other	0.4	0.9
Households-total	**30.2**	**76.1**
Wood	**25.0**	**64.1**
Fuelwood	18.3	46.9
Wood for charcoal	6.7	17.2
Wood substitutes	**5.2**	**12.0**
Crop residues	2.6	6.0
Residues for charcoal	2.6	6.0

Source: World Bank, *The Philippines: Household Energy Strategy Study* (Washington, 1992), Forest Management Bureau, Department of the Environment and Natural Resources, *Report on the 1990 Fuelwood Consumption Survey of Business Establishments* (Quezon City, 1990).

DOE has established projected estimates of consumption of fuelwood in industry and households during the period 1996-2025, summarized in table XVII.19. DOE has estimated the total energy supply from all available wood and wood-waste sources in 1995 at 78.50 million BFOE (32 million tonnes) and at 80.3 million BFOE in 1996 [6].

The estimated level of industrial use of wood in 1996, at 4.7 million BFOE, is lower than in 1990, and can therefore be considered conservative. DOE expects industrial use of fuelwood to increase by 8 per cent per annum to 33.5 million BFOE in 2025, on the basis of estimates provided by the Development Academy of the Philippines; however, there is no indication how the increase is to be achieved. Since the UNIDO mission had no access to supporting data for the above analysis, no reworking of the data has been completed.

Table XVII.19. Projected wood/wood waste supply and consumption
(Million BFOE)

Projections	1996	2000	2005	2010	2015	2025
Energy supply						
Wood/wood waste	80.30	88.15	99.79	113.71	130.50	175.00
Fuelwood consumption						
Industry	4.70	4.84	7.12	10.48	15.43	33.42
Households	42.40	44.90	48.16	51.50	54.86	61.25
Total	**47.10**	**49.74**	**55.28**	**61.98**	**70.29**	**94.67**

Source: Department of Energy, *Philippines Energy Plan 1996-2025* (Manila, 1995).

Household fuelwood use was comparable in 1990 and 1995. The estimate for household energy consumption in 1995 is based on an average consumption of wood and wood waste of 95.6 kg in the NCR, 172.39 kg in other urban areas and 213.36 kg in rural areas. Average population growth rates for the study period are estimated at 2 per cent in the NCR, 4.2 per cent in other urban centres and 1.2 per cent in rural areas.

DOE expects that 70 per cent of wood-using households will adopt improved cookstoves. This will increase efficiency of fuelwood use for cooking from 10 to 20 per cent. The level of domestic utilization of wood and wood wastes is projected to fall throughout the period with the substitution of other fuels as household incomes rise. By 2025, it is predicted that 66 per cent of rural homes will still rely on wood as their main fuel, compared with only 3.9 per cent of homes in the North Central Region and 20.7 per cent in other urban areas. In 1995, the comparable rates were 83.4 per cent for rural areas, 6.9 per cent for the North Central Region and 49.5 per cent for other urban centres. On the basis of these assumptions, wood use in households is projected to increase from 42.4 million to 61.25 million BFOE in the period 1996 to 2025 (table XVII.19).

3. Technology availability

A range of technologies are available both in the Philippines and internationally to generate heat and power from wood and wood wastes in industrial units.

The Paper Industries Corporation (PICOR) operates a total tree utilization policy in which forest and sawmill residues are burnt with black liquor to co-generate process heat and electricity [36]. They use a low-technology, sloping grate furnace and boiler unit. Similar technologies are in use in other forest and rural industries. At present, sawdust is not used, owing to its high moisture content, low energy content and lack of suitable equipment.

DOST is demonstrating a fluidized-bed wood-waste gasifier suitable for co-generation of heat and power from sawdust and lighter biomass fractions. Similarly, options exist for larger installations based on fluidized-bed combustion units, wood fuelled gasifiers and cyclone combustion units.

The Global Environment Facility is supporting development and demonstration of high-efficiency, biomass integrated gasifiers and gas-turbine units for dedicated power production at scales of 40 MW. The objective of this development programme is to improve electrical efficiency from 20 per cent to above 40 per cent, thus significantly reducing power production costs. Although such developments will have limited impact on fuelwood use in the Philippines in the short term, they may be advantageous for future dendrothermal programmes after 2000 or 2005.

Cooking and heating water on stoves is the major household end-use of energy. In 1989, wood, crop residues and charcoal accounted for 87 per cent of all household fuels, with wood producing 68 per cent of the primary energy. These biomass-based fuels are particularly important in rural communities and low income households [22]. There is a tendency to convert from biomass fuels to kerosene, liquefied petroleum gas and electricity as income levels rise. These fuels and charcoal are favoured in urban communities.

Efficiencies of wood-fuelled cooking stoves are low at around 10 per cent, compared with kerosene (40 per cent), liquefied petroleum gas (55 per cent) and electricity (70 per cent). Designs, however, are generally simple and low-cost. Prices of wood stoves were between zero and 300 pesos, with an average cost of 60 pesos, in 1990.

Higher-efficiency stoves and equipment designed for crop residues are available commercially, both in the Philippines and internationally. DOE expects an overall increase to 20 per cent cooking efficiency over a 10- to 15-year period.

4. Economic and environmental benefits

The use of fuelwood in industries such as the Paper Industries Corporation [36] replaces fuel oil and other fossil-fuel energy sources. Therefore, on the same basis as that used earlier, it is estimated that the use of fuelwood in industry reduced foreign exchange losses by $87 million in 1995, rising to $633 million in 2025.

During the same period, use of sustainably resourced fuelwood is expected to displace 2.2 million tonnes of carbon dioxide in 1995, increasing to 16.2 million tonnes in 2025. Additional short-term sequestration of carbon dioxide would be achieved with the development of forestry plantations to fuel dedicated large-scale wood-based power plants. Each hectare of high-yielding tree plantation can absorb an average of 5 to 6 tonnes of carbon dioxide per year during its establishment [28], after which time there is zero carbon-dioxide balance.

The benefits of fuelwood use in households are more difficult to derive, being dependent on the form of fuels displaced and the source of the fuelwood.

The study of household energy strategies carried out by the Energy Sector Management Assistance Programme examined the environmental impact of various household fuels [22]. It was considered that if biomass fuels are managed on a renewable basis, then a substantial indigenous energy resource base will be maintained, and the net addition of carbon dioxide and other greenhouse gases is zero. However, if fuelwood is clear-felled from steep slopes, then wood use would add significantly to carbon dioxide release. In addition, deforestation from steep hillsides would cause erosion, landslides, loss of watershed management and silting of waterways.

If fuelwood and charcoal displace imported kerosene and liquefied petroleum gas, the maximum saving in foreign exchange resulting from fuelwood use in 1995 is estimated at $792 million, rising to $1,161 million by 2025. Similarly, on the assumption that all fuelwood is harvested on a sustainable basis and displaces use of fossil fuels, there would be a net reduction in carbon-dioxide emissions of 20 million tonnes in 1995 and 29.7 million tonnes in 2025. However, it is stressed that these are only approximate, comparative estimates, as no fuels are currently imported for domestic consumption, and fossil fuels, where used, have a considerably higher thermal efficiency.

Domestic consumption of fuelwood is the largest single use of energy in the Philippines, and is therefore worthy of continued detailed analysis and assimilation into the national energy plan. As income levels increase, there is a tendency to replace fuelwood with fossil fuel sources such as liquefied petroleum gas, kerosene and electricity. This transfer could be accelerated with an expansion of rural electrification, significantly increasing fuel import bills and net release of carbon dioxide. Alternatives to uncontrolled fuel substitution should be considered and incorporated into long-term energy planning.

C. Animal wastes/manure

1. Resource availability

There is a considerable livestock population in the Philippines. This includes cattle, pigs, chickens, goats and ducks. Pigs are predominantly raised in small backyard units and cattle and ducks on a commercial scale. There are a number of commercial chicken farms. The national livestock population and total estimated biogas potential are presented in table XVII.20.

Table XVII.20. Biogas potential in the Philippines (1990)

Item	Population (thousands)	Biogas volume (million m^3 per year)	Fuel equivalent (million BFOE)	Share (percentage)
Pigs	7,988	2,069	8,323	70
Chicken	81,581	101	408	3
Cattle	1,630	253	1,016	9
Duck	7,236	15	55	1
Buffalo	2,759	428	1,724	15
Distillery Waste	-	48	195	2
Total	-	**2,914**	**11,721**	**100**

Source: United Nations Development Programme, *Financing Energy Services for Small-scale Energy Users, FINESSE: the Critical Link* (New York, 1993).

2. Technology availability

Biogas technology is already at the commercial stage in the Philippines. It is estimated that there are about 1,000 biogas units installed throughout the country, on both an industrial and a household scale. The accelerated introduction of household biogas units would be an opportunity to substitute fuelwood as a further renewable domestic fuel.

Problems have been experienced with early installations, and many are inoperative. This relates to lack of training and technical support for small-scale operations. DOE is promoting new domestic biogas installations through the network of ANECs.

ANECs will be responsible for development, promotion and installation of concrete biogas units, the advantages of which have been well demonstrated in the Philippines. ANECs will also provide technical support and servicing. The cost of the units is estimated at 10,000-15,000 pesos for a 6 m^3 installation claimed to be capable of producing 3 m^3 per day, that is, sufficient for a family with a minimum of three pigs.

DOE felt that there is insufficient demand for biogas technology to establish major markets in the domestic sector because of its high cost, complexity of operation and comparatively low cost and ease of availability of competing fuels such as fuelwood, kerosene and liquefied petroleum gas.

The major market for biogas units is considered to be for larger units suitable for agro-industrial farms, institutions and industrial units producing liquid effluent. Biogas units perform a double function in such situations, providing energy and effluent treatment. Maya Farms, an agro-industrial complex at Rizal, Luzon, has used biogas to provide 90 per cent of the energy needs of farms for a number of years.

3. *Projected resource supply and utilization*

DOE has prepared projections of animal-waste utilization for the period 1996-2025. This is presented with a UNIDO comparison in Table XVII.21. DOE estimates that supply of animal wastes will increase by an average of 1 per cent per annum during the period. Utilization rates were initially low, at approximately 2 per cent in 1995 and 3 per cent in 1996, but are projected to increase rapidly to a level of 70 per cent in 2025. The UNIDO mission considered the projections optimistic in view of DOE comments on market size and technology introduction (section 2 above) and the results of the UNDP FINESSE study [26].

Table XVII.21. Projected availability and consumption of animal wastes for energy production

Projections	1996	2000	2005	2010	2015	2025
DOE						
Energy supply (million BFOE)	11.90	12.86	12.97	13.64	14.33	15.83
Energy consumption (million BFOE)	0.50	1.66	3.21	4.92	6.79	11.08
Use (percentage)	4	13	25	36	47	70
UNIDO						
Energy consumption (million BFOE)	0.30	0.83	1.61	2.46	3.40	5.54
Use (percentage)	1	6	12	18	24	35

Sources: Department of Energy, *Philippines Energy Plan 1996-2025* (Manila, 1995); and UNIDO mission estimates.

The FINESSE study team completed an outline analysis of the economic and market potential of commercial biogas installations. It concluded that biogas use has been technically and economically proven for heat and power production. Its analysis indicated a payback of two to thee years for a range of larger unit sizes. It described a scheme to finance biogas unit installation where concessional funds would be loaned by the Development Bank of the Philippines. Under those circumstances, the team estimated that 72 installations could be completed within five years at a cost of $3.5 million, displacing 37,200 BFOE or an equivalent saving of $800,000 in foreign exchange.

The establishment of a market and an infrastructure to provide technical support and training would promote continued commercial introduction of large-scale biogas units. The FINESSE team predicted a market of 118 units within 10 years at a cost of $6.0 million (in terms of 1992 dollars). This would be equivalent to only 52,000 BFOE, well below the projected levels of DOE. The UNIDO mission reduced energy consumption by approximately 50 per cent on DOE estimates (table XVII.21). Even this adjustment may still be optimistic, but it is considered to reflect increased commercial production of livestock with associated biogas production. The UNIDO projections are more consistent with those of the FINESSE study.

4. Economic and environmental benefits

The impact of biogas production on foreign exchange savings and abatement of greenhouse gases will be relatively small within the study period. The use of biogas is estimated to have reduced foreign exchange losses by between \$2 million and \$5 million in 1995. The saving increases, in the UNIDO estimate, to between \$105 million and a maximum of \$210 million in 2025. The maximum reduction in carbon dioxide emissions is expected to be 5.36 million tonnes in 2025; in 1995, however, the use of biogas to replace kerosene reduced carbon dioxide emissions by only 60,000 to 120,000 tonnes.

5. Constraints to development

Technology for commercial biogas units is well developed both in the Philippines and internationally, and opportunities for technology transfer to promote more efficient and environmentally acceptable equipment exist. Constraints to introduction of the technology include the following:

(a) Lack of environmental penalties for discharge of effluent streams;

(b) Alternative uses for the animal wastes as organic fertilizers;

(c) Lack of awareness of available technologies;

(d) Financial requirements;

(e) Lack of technology conviction, that is, financial benefits and technical suitability.

D. Biofuels

Biomass may be used as solid, gaseous and liquid fuels. Liquid fuels produced from biomass sources are usually referred to as biofuels. There are two principal types of biofuel, namely bioethanol and biodiesel. Bioethanol is a substitute for gasoline in internal combustion engines. Biodiesel can replace diesel (gas oil) in vehicles and electricity generating sets.

Bioethanol is an alcohol produced by fermentation of sugars present in biomass materials. The main crops suitable for ethanol production in the Philippines include sugar cane and molasses, corn and corn residues and cassava starch.

The Government of the Philippines has completed a number of trials on ethanol use as a gasoline substitute and extender, including a brief period during the early 1970s, when ethanol blends were introduced commercially in Negros. Since, however, the high cost of ethanol production and the relatively low price of petroleum do not make this an attractive fuel in the foreseeable future, it is not included in the projections of biomass energy use.

Biodiesel is produced from vegetable oils such as coconut and soybean oil. The Philippines has completed a number of development trials on various forms and mixes of coconut oil and diesel for use in vehicles and small generating sets. There are no technical problems with the use of refined coconut oil in high blends with diesel or the methyl ester of coconut oil as a total replacement for diesel.

However, the high price of coconut oil (and other food-based oils) mitigates against biodiesel use as a fossil fuel replacement. For that reason, biodiesel is not included in the projections of biomass utilization.

E. Summary of biomass energy developments

In the foregoing sections, specific biomass resources and energy end-uses have been considered in some detail. In the present section, a summary of biomass energy supply and consumption, the state of technology development and the benefits of biomass energy use are presented.

1. Supply and consumption of biomass energy

The projections for supply and consumption of biomass energy resources for the period 1995-2025 are summarized in tables XVII.22 and XVII.23.

In 1995, on the basis of conservative estimates for wood and wood waste availability, total biomass energy supply was equivalent to between 130 million and 167 million BFOE, or from 67 per cent to 85.5 per cent of national energy demand (195 million BFOE) (table XVII. 22). By 2025, with expanded agricultural production and sustained timber availability, the supply of biomass is projected to increase to 289 million BFOE by DOE, and to 337 million BFOE by the UNIDO mission. This represents a decline, however, to between 21 and 24 per cent of the projected total energy demand during the same period.

In 1995, consumption of all biomass energy resources was estimated at 60 million BFOE by DOE, and at a slightly lower (6.5 per cent) 56 million BFOE by the UNIDO mission (table XVII.23). This discrepancy is primarily based on differences in the use of rice hulls and coconut wastes as energy resources. DOE projects that consumption of biomass resources will increase to 181 million BFOE by 2025, the largest increases occurring in the industrial sector (table XVII.24). Industrial end-uses of biomass, including power co-generation, was estimated at 18 million BFOE in 1995 and is projected to increase to 109 million BFOE in 2025.

The UNIDO mission considered the DOE estimates to be optimistic, with their expected high proportion of use of the selected resources. The UNIDO estimate for biomass use in industry was 22 per cent lower for 1995 and 25 per cent lower for 2025. Biomass use in industry, however, will overtake household use by the end of the period.

The DOE projections for biomass use in the domestic sector were accepted. Domestic use of fuelwood represents the largest end-use of biomass resources throughout the study period, being from 69 to 74 per cent of biomass energy consumption in 1995 (table XVII.25). Although falling to between 34 and 39 per cent of total biomass consumption in 2025, this is still equivalent to 61 million BFOE, or 4 per cent of the national energy demand.

Table XVII.22. Summary of biomass energy supply projections (1995-2025)
(Million BFOE)

Projections	1995	1996	2000	2005	2010	2015	2020	2025
DOE								
Residues								
Rice	7.0	7.3	8.5	10.3	12.6	15.3	18.6	22.7
Sugar	10.6	11.0	12.9	15.7	19.0	23.2	28.2	34.3
Coconut	18.1	18.5	20.0	22.1	24.4	26.9	29.7	32.8
Wood/wood waste	78.5	80.3	88.2	99.8	113.7	130.5	150.7	175.0
Animal waste	11.8	11.9	12.4	13.0	13.6	14.3	15.1	15.8
Black liquor	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Municipal waste	3.8	3.9	4.4	5.0	5.7	6.4	7.1	7.9
Total	**130.0**	**133.1**	**146.6**	**166.0**	**189.2**	**216.8**	**249.6**	**288.7**
UNIDO mission								
Residues								
Rice	29.6	32.9	36.7	40.5	44.7	49.4	54.5	60.2
Sugar	25.2	25.7	27.8	30.7	33.9	37.4	41.3	45.6
Coconut	17.9	18.1	19.3	20.7	22.3	24.1	25.9	27.9
Wood/wood waste	78.5	80.3	88.2	99.8	113.7	130.5	150.7	175.0
Animal waste	11.8	11.9	12.4	1.0	13.6	14.3	15.1	15.8
Black liquor	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Municipal waste	3.8	3.9	4.4	5.0	5.7	6.4	7.1	7.9
Total	**177.0**	**172.9**	**188.8**	**209.9**	**234.2**	**262.3**	**294.8**	**332.6**

Table XVII.23. Summary of biomass energy supply and demand projections
(Million BFOE)

Projections	1995	1996	2000	2005	2010	2015	2020	2025
DOE								
Residues								
Rice	2.4	2.5	3.4	4.8	6.5	8.9	11.9	15.9
Sugar	5.5	5.9	7.4	9.9	13.1	17.2	22.4	29.1
Coconut	5.4	5.8	7.3	9.6	12.2	15.3	18.8	23.0
Fuelwood (industrial)	4.6	4.7	4.8	7.1	10.5	15.4	22.7	33.4
Fuelwood (domestic)	41.8	42.4	44.9	48.2	51.5	54.9	58.9	61.3
Animal waste	0.3	0.5	1.7	3.2	4.9	6.8	8.8	11.1
Black liquor	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Municipal waste	--	--	--	--	2.9	4.4	5.1	7.3
Total biomass energy supply	**60.2**	**62.0**	**69.7**	**83.0**	**101.8**	**123.1**	**148.8**	**181.3**
Total energy demand	**195.0**	**219.9**	**301.4**	**403.4**	**552.4**	**768.2**	**1,053.2**	**1,392.4**
UNIDO mission								
Residues								
Rice	0.5	0.5	2.2	2.8	3.6	4.7	6.1	7.9
Sugar	6.9	7.2	8.6	10.6	13.2	16.5	20.6	25.8
Coconut	2.0	2.1	2.6	3.1	3.9	4.9	6.3	8.1
Fuelwood (industrial)	4.6	4.7	4.8	7.1	10.5	15.4	22.7	33.4
Fuelwood (domestic)	41.8	42.4	44.9	48.2	51.5	54.9	58.2	61.3
Animal waste	0.1	0.3	0.8	1.6	2.5	3.4	4.4	5.5
Black liquor	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Municipal waste	--	--	--	--	2.9	4.4	5.1	7.3
Total biomass energy supply	**56.1**	**57.4**	**63.9**	**73.6**	**88.3**	**104.4**	**123.6**	**149.5**

Source: Department of Energy, *Philippines Energy Plan 1996-2025* (Manila, 1995) and UNIDO mission estimates.

Table XVII.24. Projected sectoral end-use of biomass energy
(Million BFOE)

Projections	1995	1996	2000	2005	2010	2015	2020	2025
DOE								
Domestic	42	43	47	51	56	62	67	72
Industrial	18	19	23	32	45	61	81	109
UNIDO mission								
Domestic	42	43	46	50	54	58	63	67
Industrial	14	15	18	24	34	46	61	83

Source: Department of Energy, *Philippines Energy Plan 1996-2025* (Manila, 1995) and UNIDO mission estimates.

Table XVII.25. Projected biomass energy consumption
(Percentage of total biomass consumption)

Projections	1995	1996	2000	2005	2010	2015	2020	2025
DOE								
Residues								
Rice	4	4	5	6	6	7	8	9
Sugar	9	9	11	12	13	14	15	16
Coconut	9	9	11	12	12	12	13	13
Fuelwood (industrial)	8	8	7	9	10	13	15	18
Fuelwood (domestic)	69	68	64	58	51	45	39	34
Animal waste	--	1	2	4	5	6	6	6
Black liquor	--	--	--	--	--	--	--	--
Municipal waste	--	--	--	--	3	4	3	4
UNIDO mission								
Residues								
Rice	1	1	3	4	4	4	5	5
Sugar	12	13	13	4	15	16	17	17
Coconut	4	4	4	4	4	5	5	5
Fuelwood (industrial)	8	8	8	--	12	15	18	22
Fuelwood (domestic)	74	74	70	65	58	53	47	41
Animal waste	--	--	1	2	3	3	4	4
Black liquor	--	--	--	--	--	--	--	--
Municipal waste	--	--	--	--	3	4	4	5

Source: Department of Energy, *Philippines Energy Plan 1996-2025* (Manila, 1995) and UNIDO mission estimates.

The importance of biomass as a national energy resource falls throughout the study period (table XVII.26), as a result of the expansion of other indigenous fuels and the levels of fossil-fuel imports maintained to meet the expected demand for power generation and transport fuels. However, total use of biomass fuels is expected to remain a significant part of the energy mix of the Philippines throughout the period, being 31 per cent in 1995 and between 11 and 13 per cent in 2025.

The potential for power generation either for internal use or for sale to the grid was considered to be high in the rice and sugar industries. There would also be potential for power generation in the timber and coconut industries. In fact, the integrated timber company, PICOP, already produces its heat and power requirements from forest and sawmill residues. The sugar industry has the greatest immediate potential for commercial sales to the grid. Preliminary estimates of from 80 to 120 MW installed within 10 years could replace diesel generating sets planned for that period.

A number of factors encourage increased biomass fuel use in industry, including the following:

(a) Burning of biomass is an integral part of the production process;

(b) Biomass is cheaper than commercial energy;

(c) Biomass energy supply is more reliable than commercial energy;

(d) Low capital investment is required for biomass fuel systems;

(e) Biomass is produced as a waste product;

(f) Energy use is the most appropriate method of residue disposal.

There is considerable potential for increasing the use of biomass as a source of heat and power within both the agroprocessing industries that generate the residues and the associated energy-intensive industries in rural locations.

More efficient utilization of biomass resources would be advantageous for a number of reasons, such as the following:

(a) Intensification of energy use with development would not increase fossil fuel imports and use;

(b) Availability of residues at a single location could provide the energy to promote development of small- and medium-scale industry;

(c) Low-cost energy based on biomass could enhance economic performance of industry;

(d) Cost-effective removal of wastes and environmental pollutants;

(e) Improved sustainability of industrial activity, based on renewable energy resources.

The agroprocessing and rural industries with the highest potential for utilizing biomass energy resources in the Philippines are those which meet the following conditions:

(a) They produce significant quantities of dry or storable residues that do not have high-value, existing commercial uses;

Table XVII.26. Biomass energy supply
(Percentage of total energy demand)

Projections	1995	1996	2000	2005	2010	2015	2020	2025
DOE								
Residues								
Rice	1	1	1	1	1	1	1	1
Sugar	3	3	2	2	2	2	2	2
Coconut	3	3	2	2	2	2	2	2
Fuelwood (industrial)	2	2	2	2	2	2	2	2
Fuelwood (domestic)	21	19	15	12	9	7	6	4
Animal waste	--	--	1	1	1	1	1	1
Black liquor	--	--	--	--	--	--	--	--
Municipal waste	--	--	--	--	1	1	--	1
Total	**30**	**28**	**23**	**20**	**18**	**16**	**14**	**13**
UNIDO Mission								
Residues								
Rice	--	--	1	1	1	1	1	1
Sugar	4	3	3	3	2	2	2	2
Coconut	1	1	1	1	1	1	1	1
Fuelwood (industrial)	2	2	2	2	2	2	2	2
Fuelwood (domestic)	21	19	15	12	9	7	6	4
Animal waste	--	--	--	--	--	--	--	--
Black liquor	--	--	--	--	--	--	--	--
Municipal waste	--	--	--	--	1	1	--	1
Total	**28**	**25**	**22**	**19**	**16**	**14**	**12**	**11**

Source: Department of Energy, *Philippines Energy Plan 1996-2025* (Manila, 1995) and UNIDO Mission estimates.

(b) They are adjacent to industries producing a surplus combustible biomass waste;

(c) They either have high demand for heat and power or are adjacent to commercial end-users of energy;

(d) They are located in areas where existing energy costs are high or energy supply is unreliable;

(e) They have an opportunity to sell surplus energy at commercial rates to the national grid or third parties;

(f) They are using old, unreliable equipment suitable for replacement or retrofitting with high-efficiency equipment.

On the basis of the literature surveyed and the discussions held during the case study, the greatest immediate commercial potential to use biomass energy resources appears to involve the following:

(a) Introduction of high-efficiency co-generation equipment to use sugar-cane bagasse;

(b) Small-scale (200 kW) to medium-scale (2-5 MW) equipment to use rice hulls (and straw) for rice mills and small industry in rural and periurban areas;

(c) Kilns and combined heat and power equipment for sawmills and timber-processing factories;

(d) Improved biomass burning equipment for copra driers, waste-heat recovery equipment for coconut charcoal production and gasification of coconut wastes;

(e) Industrial-scale biogas units for integrated animal-production complexes and institutions such as prisons, schools and community centres;

(f) Introduction of higher-efficiency cooking stoves for rural and periurban areas to improve the use of fuelwood and residue resources and reduce carbon dioxide emissions.

2. Biomass technology availability and development

During the consideration of each major biomass energy resource and end-use, brief references were made to availability of specific technologies and ongoing developments in the Philippines and internationally. In general, it was considered that technology availability is not a limiting factor on either short- or medium-term development of biomass energy utilization.

The Philippines have been evaluating the utilization of biomass energy resources and conversion technologies since the early 1970s, and have developed, introduced and tested a wide range of appropriate commercial energy options, which are summarized in table XVII.27.

In addition, commercial groups such as the rice, sugar-cane and livestock industries have access to internationally proven technologies for high-efficiency conversion of their respective biomass resources. Joint-venture opportunities are under evaluation by those industries, and programmes such as the EC/ASEAN COGEN and Winrock International-Regional Energy Project Support Office are promoting proven technologies for smaller-scale energy resources in the rice, coconut and timber industries.

Table XVII.27. Assessment of biomass energy technologies in the Philippines

Technology	Resource	Applications	Stage of development				
			T	P	D	V	C
Improved cooking stoves	Fuelwood	Household/cooking				x	
	Rice hulls	Household/cooking				x	
Biogas systems	Animal manure	Household/heat			x		
	Manure/stillage	Industrial/heat				x	x
		Industrial/power				x	x
Gasification systems	Charcoal	Process heat				x	
	Rice hulls	Heat			x		
	Wood/wood wastes	Heat/power		x	x		
Direct combustion systems	Wood	Heat/steam/power					x
	Charcoal	Process heat					x
	Bagasse	Heat/steam/power					x
	Coconut shell/husk	Heat/power					x
	Coconut shell/charcoal	Waste heat recovery		x		x	
	Rice hull	Heat/power				x	x
	Rice hull	Heat/power			x	x	
	Briquettes	Heat/power			x	x	
Biofuel systems	Sugars/oils	Transport/power				x	
Pyrolysis	Wood wastes	Heat/power	x				
Liquefaction	Biomass	Heat/power	x				

Source: R. Quejas, Director of NCED, DOE, and UNIDO mission estimates.

Note: T: ongoing technical and laboratory-scale studies.
P: technical feasibility proven by pilot studies.
D: technical feasibility proven by demonstration projects.
V: proven competitive with conventional systems, ready for commercialization.
C: commercial technologies.

The development and introduction of technology is an ongoing process, as shown by DOST interest in developing expertise and experience in liquefaction and pyrolysis conversion technologies. International development and demonstration programmes for larger-scale production of electricity using high-efficiency gasification and combined gas-cycle and advanced fluidized-bed combustion units based on dedicated supplies of energy crops, particularly fast-growing timber species and short-rotation coppice crops, may have an impact on biomass energy use in the Philippines. These technologies, however, must first be adequately demonstrated to prove their technical and financial viability

Also, problems related to land ownership and production of large scale plantations for fuelwood require resolution. Prior to the early twenty-first century, therefore, it cannot be expected that they will have much of an impact on the abatement or avoidance of carbon dioxide emissions by new fossil-fuelled power plants.

3. Benefits of biomass energy utilization

The use of biomass energy resources as part of a national energy mix can provide a number of direct and indirect benefits. These are not usually incorporated in standard economic evaluations of energy production projects. The financial benefit of fuels to the end consumer should reflect the benefits or costs to the country and the international community. The application of external prices to reflect the perceived benefits and costs of the use of the respective fuels would encourage development of biomass energy resources. It is not the purpose of the present case study to develop a methodology for evaluation of the various benefits and costs related to biomass energy resource use. However, an indication of some of the main benefits is presented below to indicate the potential value of biomass resource utilization.

Environmental benefits

Abatement of greenhouse gas emissions. Carbon dioxide is one of the major greenhouse gases, and its increasing release through use of fossil fuels is one factor affecting climate change and global warming. When biomass energy resources are produced on a sustainable basis, they do not contribute to global warming, as the carbon dioxide released on combustion is balanced by that absorbed during their growth. Where biomass energy resources displace fossil fuels, there will be a net reduction in carbon dioxide. Biogas technology has the double benefit of reducing methane release from untreated animal wastes and of displacing fossil fuels.

A study by the Asian Development Bank on climate change in Asia [27] has reviewed the overall level of greenhouse gas emissions for the region in 1990, and discussed the major mitigation activities. The estimated commercial release of carbon dioxide in the Philippines was between 75.2 million and 88.6 million tonnes. Activities in the energy and industrial sectors were responsible for the greatest proportion (67-79 per cent) of the emissions (59.8 million tonnes of carbon dioxide). Combustion of fuels in the commercial energy sector released the equivalent of 37.1 million tonnes of carbon dioxide [28], in addition to carbon dioxide release from fuelwood and other biomass sources in the non-commercial sector.

The World Bank and the Asian Development Bank are funding a major regional programme on the least-cost options for abatement of greenhouse gas emissions. In that connection, a study will be conducted to establish baselines for greenhouse gas emissions and sinks in 14 countries in the region. Possible actions and projects to reduce such emissions or create new carbon dioxide sinks will be identified for future funding. The study may provide further evidence and funding to support biomass energy initiatives.

Estimates of reduction in carbon dioxide emissions through displacement of fossil fuels by individual biomass fuels are presented in table XVII.28, and are summarized for the domestic and industrial (including power) sectors in table XVII.29. Only the crudest estimates are presented, as they are based on the assumption that all biomass fuels, including household fuels, replace fossil fuels. A more accurate evaluation would include analysis of end-use sectors, and incorporate both the efficiency of fuel usage and the form of fuel displaced.

If all energy requirements in 1996 in the Philippines were produced from fossil fuel sources, total carbon dioxide emissions would amount to an estimated 106.4 million tonnes. Of this total, 61 per cent is caused by irreversible releases from fossil fuel sources. Renewable energy resources, therefore, caused an estimated effective reduction in net carbon dioxide emissions of 41.7 million tonnes in 1996. Biomass resources accounted for 73 per cent of the carbon dioxide abatement potential.

Table XVII.28. Estimated reduction of carbon-dioxide emissions
(Million tonnes)

Projections	1995	1996	2000	2005	2010	2015	2020	2025
DOE								
Rice	1.2	1.2	1.6	2.3	3.2	4.3	5.8	7.7
Sugar	2.7	2.8	3.6	4.8	6.3	8.3	10.9	14.1
Coconut	2.6	2.8	3.5	4.6	5.9	7.4	9.1	11.1
Fuelwood (industrial)	2.2	2.3	2.3	3.4	5.1	7.5	11.0	16.2
Fuelwood (domestic)	20.2	20.5	21.7	23.3	24.9	26.6	28.1	29.6
Animal waste	0.1	0.3	0.8	1.6	2.4	3.3	4.3	5.4
Black liquor	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Municipal waste	--	--	--	--	1.4	2.1	2.5	3.5
Total biomass	**29.1**	**30.0**	**33.8**	**40.1**	**49.3**	**59.5**	**71.7**	**87.7**
Total energy demand	**94.4**	**106.4**	**145.9**	**95.3**	**67.4**	**371.8**	**509.8**	**673.9**
UNIDO mission								
Rice	0.2	0.3	1.1	1.4	1.8	2.3	2.9	3.8
Sugar	3.4	3.5	4.2	5.1	6.4	8.0	10.0	12.5
Coconut	1.0	1.0	1.2	1.5	1.9	2.4	3.0	3.9
Fuelwood (industrial)	2.2	2.3	2.3	3.4	5.1	7.5	11.0	16.2
Fuelwood (domestic)	20.2	20.5	21.7	23.3	24.9	26.6	28.1	29.6
Animal waste	0.1	0.1	0.4	0.8	1.2	1.6	2.1	2.7
Black liquor	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Municipal waste	--	--	--	--	1.4	2.1	2.5	3.5
Total biomass	**27.2**	**27.7**	**31.0**	**35.7**	**42.7**	**50.5**	**59.7**	**72.4**

Sources: Department of Energy, *Philippines Energy Plan 1996-2025* (Manila, 1995); and UNIDO mission estimates.

Table XVII.29. Sectoral analysis of estimated reductions in carbon-dioxide emissions
(Million tonnes)

Estimated reductions	1995	1996	2000	2005	2010	2015	2020	2025
Estimates for industry								
DOE	8.8	9.2	11.2	15.3	22.0	29.7	39.3	52.7
UNIDO	6.9	7.1	8.9	11.6	16.6	22.3	29.5	40.0
Estimates for households								
DOE	20.3	20.8	22.5	24.9	27.3	29.8	32.4	35.0
UNIDO	20.3	20.6	22.1	24.1	26.1	28.2	30.3	32.3
Totals								
DOE	29.1	30.0	33.7	40.1	49.3	59.5	71.7	87.7
UNIDO	27.2	27.7	31.0	35.7	42.7	50.5	59.8	72.3

Sources: Department of Energy, *Philippines Energy Plan 1996-2025* (Manila, 1995); and UNIDO mission estimates.

Total potential release of carbon dioxide is projected to increase to an estimated 674 million tonnes in 2025, on the basis of energy consumption of 1,392 million BFOE. This estimate could be reduced by 29 million tonnes of carbon dioxide through energy conservation, and by a further 67 million tonnes through the use of geothermal, hydropower and nuclear energy resources. The maximum projected consumption of biomass energy resources is estimated at 181 million BFOE. This represents a possible net reduction of 87.7 million tonnes of carbon dioxide, equivalent to 15 per cent of the expected carbon dioxide emissions from fossil fuels. It balances the expected contribution of other renewables and energy conservation, thus demonstrating the importance of biomass in the abatement of greenhouse gas emissions.

The above-mentioned benefits would be increased with the development of energy crop plantations for future dendrothermal power plants. Plantations take 6 to 15 years to establish, during which time they sequester carbon dioxide in the growing biomass and soil beneath the canopy. Fast-growing species take up between 5 and 6.5 tonnes of carbon (21 tonnes of carbon dioxide) per hectare per year.

Reduced air pollution. The burning of fossil fuels releases a number of air pollutants such as sulphur dioxide, nitrous oxides and carbon monoxide. The use of biomass to displace fossil fuel combustion has the potential to alleviate release of the pollutants. The level of reduction varies considerably between fuels displaced and combustion technologies. Therefore, no quantitative estimates are made in the report.

Land restoration and biodiversity. The production of dedicated biomass crops has the potential to restore denuded and degraded lands and to improve watershed management. Similarly, well-planned energy crop plantations can improve landscapes and enhance biodiversity and amenity values in areas adjacent to urban settlements.

Socio-economic benefits

Foreign exchange savings. Development of commercially viable, cost-effective indigenous fuels is a cornerstone of the energy policy of the Philippines. It is considered important for the establishment of a secure and sustainable energy supply mix to support economic development and to reduce expenditure of foreign exchange on imported fuels.

It has been calculated that the landed price of imported fuel is equivalent to $18.96 per barrel of fuel oil. An estimate of maximum foreign exchange savings through current and projected biomass use is presented in table XVII.30 and summarized for the domestic and industrial sector in table XVII.31. This preliminary analysis assumes that all biomass fuels replace imported fuels; it is therefore only an initial and comparative guide. A more detailed analysis would need to consider not only each end-use sector and fuel displaced, but also a more accurate allocation of local and foreign-exchange costs for each fuel. It is estimated that the potential savings due to consumption of biomass fuels were approximately $1,100 million in 1995, and should rise to between $2,835 million and $3,436 million in 2025. This is equivalent to 19-23 per cent of the probable fuel import bill in 2025.

The current level of biomass energy utilization in industry reduces foreign exchange losses by between $269 million and $343 million, or 34-43 per cent of biomass use in the domestic sector. Biomass use in industry is expected to increase throughout the study period at a faster pace than in the domestic sector, with concomitant increases in potential savings of foreign exchange to between $1,569 million and $2,065 million. This is between 55 and 60 per cent of the projected savings from use of biomass energy resources in the Philippines.

Table XVII.30. Estimated foreign exchange savings from biomass energy resources
(Million dollars)

Item	Projected consumption levels							
	1995	1996	2000	2005	2010	2015	2020	2025
UNIDO Mission								
Rice	9	10	42	54	69	89	115	150
Sugar	131	137	163	202	251	312	391	490
Coconut	38	40	48	60	74	93	119	153
Fuelwood (industrial)	87	88	92	135	199	293	431	634
Fuelwood (domestic)	792	804	851	913	976	1,040	1,103	1,161
Animal waste	2	5	16	30	47	64	84	105
Black liquor	3	3	3	3	4	4	4	4
Municipal waste	--	--	--	--	55	83	97	138
Total	**1,062**	**1, 087**	**1,215**	**1,397**	**1,675**	**1,978**	**2,344**	**2,835**
DOE								
Rice	45	48	5	90	124	168	226	301
Sugar	105	112	141	188	248	326	425	552
Coconut	103	110	139	181	231	289	357	436
Fuelwood (industrial)	87	88	92	135	199	293	431	634
Fuelwood (domestic)	792	804	851	913	976	1,040	1,103	1,161
Animal waste	5	10	31	61	93	129	168	210
Black liquor	3	3	3	3	4	4	4	4
Municipal waste	--	--	--	--	55	83	97	138
Total	**1,140**	**1,175**	**1,262**	**1,571**	**1,930**	**2,332**	**2,811**	**3,436**

Sources: Department of Energy, *Philippines Energy Plan 1996-2025* (Manila, 1995); and UNIDO mission estimates.

Table XVII.31. Projected foreign exchange savings by sector
(Million dollars)

Item	Projections consumption levels							
	1995	1996	2000	2005	2010	2015	2020	2025
Industry								
DOE	343	361	439	598	861	1,162	1,539	2,065
UNIDO	269	278	348	453	651	874	1,156	1,569
Households								
DOE	797	814	883	974	1,070	1,169	1,270	1,371
UNIDO	794	809	867	943	1,023	1,105	1,186	1,266
Total								
DOE	1,140	1,174	1,322	1,572	1,900	2,331	2,810	3,436
UNIDO	1,064	1,087	1,215	1,397	1,674	1,979	2,342	2,835

Source: UNIDO mission estimates.

Job and rural industry creation. In addition to foreign exchange savings, the development of biomass resources could have significant effects on job and wealth creation in rural areas. The impact of these developments on the local economy could only be analysed on a case-by-case basis, as the effect of a new dendrothermal plant would be significantly different from improved co-generation in an existing sugar factory.

In general, it is estimated that for household fuels, 0.63 to 1.1 person-days of employment are generated per BFOE consumed as fuelwood and 2 person-days for charcoal, compared with 0.06 person-days for imported petroleum fuels and 0.19 person-days for coal [22]. Displacement of imported fossil fuels by biomass resources would therefore benefit both the national and rural communities.

Energy security

Enhanced use of biomass energy resources provides the Philippines with a measure of fuel supply security. Consumers would have increased choice in fuel and technology selection. It may be expected that increased competition between fuels would also reduce swings in fuel supply costs.

XVIII. CONCLUSIONS AND RECOMMENDATIONS

A. Conclusions

In the introduction to the present case study, a number of criteria were suggested as essential to the development of renewable energy, particularly biomass resources, in a country. The analysis presented in the previous sections suggests that the Philippines meets the majority of the criteria, and that conditions are suitable for high levels of biomass utilization in the future.

The Philippines is experiencing rapid economic growth with associated high demand for new energy supplies, particularly electricity. Although the country is well endowed with biomass energy resources, there are only limited indigenous supplies of traditional energy resources. Therefore, higher energy demand will require increased imports of fossil fuels.

The inclusion of fuelwood in statistics on the supply and use of national energy resources has demonstrated the overall importance of biomass to the energy mix in the Philippines. Biomass, particularly agroprocessing residues, wood and wood wastes and animal wastes from commercial units, has the potential to make a further significant impact on the total energy supply mix in the short term. Fuelwood is the least-cost source of energy for cooking and heating water in households, and is therefore likely to remain the dominant energy source, particularly in rural areas. There is an opportunity for more efficient combustion systems, but their currently high cost, compared with that of equipment based on fossil fuel, will continue to be a major barrier.

Residues are increasingly cost-competitive as an energy source in agro-industry, especially where surplus power can be sold to the grid and to third parties at attractive rates. The displacement of imported fossil fuels by sustainably produced biomass energy resources provides a number of economic and environmental benefits as measured by reductions in foreign exchange losses and carbon dioxide emissions. Use of biomass in industry could save the Philippines over $2 billion (in terms of real 1995 dollars), and reduce carbon dioxide emissions by up to 50 million tonnes by 2025. Household consumption of fuelwood has an equivalent impact in both respects, although the effects are less clear since imported fuels are not being displaced.

Technologies for the conversion of biomass resources into useful energy forms for the different end-use sectors have been demonstrated. The sectors, particularly the major agroprocessing industries, have also been the subject of an extensive prefeasibility study, and commercial projects have been identified. In addition, the current international interest in demonstrating and disseminating efficient, environmentally friendly biomass technologies will benefit countries with a large biomass resource base, such as the Philippines.

DOST referred to the difficulties involved in the identification and accreditation of reliable and reputable manufacturers to commercialize demonstrated technologies. It is essential to have a broad manufacturing base for a range of competing technologies if biomass use is to develop and thrive.

The Government of the Philippines has achieved great success during the last two to three years in resolving a severe shortage of electricity through the opening of the power-supply industry to the private sector. National policy continues to stress the key role of the private sector and independent power production in future energy developments.

The Government has already strengthened the administration of the energy sector through the establishment of DOE to prepare long-term energy plans and to coordinate and monitor energy development strategies. NCED is responsible for the promotion of new and renewable energy sources, including biomass. It is highly active in establishing priority areas, commercializing proven energy technologies and encouraging private-sector involvement in biomass energy development.

The Government, through BOI, has established policies to promote priority industrial areas. Industries producing renewable energy equipment and those using biomass resources for generation of heat and power are allocated pioneer status. As such, they receive the financial incentives described in earlier sections.

The stability of the Government and its recent development of increasingly liberal macroeconomic policies has won it the support of the major international agencies. A number of non-governmental organizations, industry associations and private groups have been established, and are active in promoting the biomass energy sector. International groups such as EC/ASEAN COGEN and Winrock International are stimulating private-sector involvement in commercialization of renewable and biomass energy technologies. At the same time, the major international development and aid agencies are considering support for small-scale energy technologies, as exemplified by UNDP promotion of the Financing Energy Services for Small-scale Energy Users (FINESSE) [26] and the involvement of the World Bank and the Energy Sector Management Assistance Programme in the evaluation of biomass energy systems [21] and in strategies for household energy supply [22].

Long-term energy plans have been prepared placing high priority on development of indigenous energy resources, including non-conventional energy sources such as biomass. Rural development and the need for commercially viable, environmentally sensitive energy resources and projects are stressed in all government statements.

The Government has been highly successful in dealing with the recent power crisis through increased economic liberalization, fiscal reform and involvement of the private sector. A similar commitment to renewable energy development would make it possible to realize the aggressive projections of DOE for future biomass use, particularly in the major agroprocessing and forest industries. There are, however, a number of constraints to biomass use, particularly in the industrial and power sectors. Support from the international community will assist in removing those barriers and in accelerating biomass energy use in the Philippines.

In discussing the issues, all representatives of the Government, of non-governmental organizations and of the private sector strongly supported biomass energy use in both the domestic and industrial sectors. The constraints referred to below must therefore not be seen as major obstacles to continued development of a vibrant biomass energy sector. They demonstrate, rather, the need for additional promotion and dissemination of positive technical and economic information and for the increased availability of concessional sources of finance to stimulate private-sector activity.

Constraints to biomass energy use may be summarized as follows:

(a) Poor perception of biomass energy resources, viewed as involving:

(i) Wastes of little or no commercial value and with no penalty for disposal;
(ii) Low-quality fuels with low energy density and content;
(iii) High cost of collection, transport and handling;
(iv) Difficult and dangerous to store;
(v) Dirty fuels inferior to competitive fossil fuels and electricity;

(b) Lack of technology awareness:

(I) Conversion technologies perceived as old and inefficient;
(ii) Poor previous experiences of inadequately developed equipment;
(iii) Capital costs of equipment are high compared to competitive fossil-fuelled equipment;
(iv) Poor quality of locally available equipment;
(v) Low efficiency of biomass energy equipment;
(vi) No information available on technical and economic performance of improved biomass technologies;

(c) Lack of technology support:

(I) Limited numbers of reputable and reliable local manufacturers;
(ii) No reliable proven local equipment;
(iii) Inadequate technical support, maintenance and spares for imported or internationally sourced technology;
(iv) Non-existent or limited training facilities;

(d) Poor financial performance:

(I) High capital costs, low financial returns and long payback periods;
(ii) Lack of capital resources in the agro-industrial sector;
(iii) Limited access to loans;
(iv) High cost of borrowing;
(v) Lack of access to foreign exchange;
(vi) Low and subsidized costs of competing fuels;

(e) Government policy:

(I) Cross-subsidy policy for domestic fuels favouring fossil-fuel use;
(ii) Budgetary constraints on government departments;
(iii) Inadequate training and manpower development policies;
(iv) Concentration on large-scale power and resource developments;
(v) Inadequate provision of concessional finance to biomass projects.

B. Recommendations

The UNIDO mission considered that, in order to accelerate the introduction of biomass use in the Philippines, support measures are required to promote technology awareness and availability and to strengthen and expand the activities of existing government and private-sector agencies. In addition, there should be a clear monetary commitment from the Government through increasing access to sources of concessional finance and modification of fuel-pricing policies to encourage use of indigenous fuels.

A brief review of areas in which action is required is presented below.

1. Technology promotion

The promotion of biomass technology requires development, demonstrations, dissemination and training. Funds are required to accelerate the rate of R & D and commercial demonstration of a range of technologies for biomass energy conversion. The role of the private sector in the promotion of technology should be enhanced, so that successful results can be disseminated directly to key markets. Funds could be applied through a mix of relevant government departments and agencies and through industry associations.

The results of successful demonstrations, both in the Philippines and internationally, would need to be disseminated through the relevant industry associations, academic institutions and the ANEC system. Those institutions should also be responsible for training decision makers in options for energy supply and evaluation of new technologies.

2. Technology availability and transfer

Technology availability and transfer will involve the following:

(a) Expansion and strengthening of the local manufacturing base;

(b) Incentives to international suppliers of energy equipment to establish local joint ventures and agencies;

(c) Establishment of energy service and support firms.

Mechanisms should be sought to promote the involvement of small- and medium-scale industry in equipment manufacture and marketing systems. The involvement of PADISCOR in the promotion of equipment for burning rice hulls and the success of ANECs testifying to the potential for the private sector to develop biomass energy use. Similarly, there is an increasing participation of companies in the private sector providing energy consultancy and development services. These companies have a vested interest in identifying and servicing new energy markets and lobbying on behalf of potential clients (both suppliers and consumers) to promote supportive policies at the national level. These activities are closely linked to identification of improved technology options and establishment of commercial links with international sources of equipment and technology. Mechanisms should therefore be sought to promote private-sector activity in manufacturing and equipment supply and provision of energy services. The potential may exist for the privatization of some of the activities of existing government agencies and ANECs where they have an impact on the commercialization of technology and the provision of energy support services.

3. Strengthening of institutional support

Institutional support is required to ensure: resource and market definition; database and databank development; expansion of training programmes; information dissemination; provision of technical support and advice; manpower development; and development of planning and programme implementation skills.

Although there is a strong knowledge base and high level of activity in the main government agencies, particularly in NCED, workloads are heavy. There is a continuing requirement to maintain and increase levels of trained manpower and the provision of equipment and facilities to support development of data and information resources. The data are essential to the accuracy of future programme and project planning.

International agencies have provided considerable support from manpower and infrastructure development in recent years, and it is strongly recommended that such support be continued. The private sector should be encouraged to play an increasing role in the provision of training and manpower development skills and support services to the energy sector, to enable the country to achieve self-sufficiency in this essential area.

4. Availability of finance

Energy pricing policies

A detailed reevaluation of energy pricing policies is recommended with a view to establishing mechanisms to promote the use of indigenous fuels, without adverse consequences for rural and poorer sectors of the population.

The factors affecting decisions on energy pricing and biomass project development could be changed in various ways, including:

(a) Removal of cross-subsidies between fossil fuels;

(b) Application of full external cost benefits to indigenous fuel sources;

(c) Development of advantageous, or promotional, small power-purchase agreements for biomass-based, private power production. Such agreements would include financial rewards for methane avoidance and reduction of carbon dioxide emissions, as well as avoided cost benefits;

(d) Penalties for disposal and dumping of biomass waste resources.

Enhanced investment incentives

In response to government policies to promote environmentally sound, indigenous energy resources, it may be appropriate to establish enhanced "fast-track" incentives for biomass energy projects (both equipment supply and energy production). Such incentives would include guaranteed power purchase agreements, ease of accreditation, longer tax holidays and accelerated depreciation allowances.

Increased availability of project financing

It was noted, particularly by the private sector, that although the Government has provided policy support to biomass energy development, it has not provided the necessary financial support to stimulate such development. The international and regional development banks have provided extensive financial support to renewable energy programmes in the Asian region. Funds for this purpose would probably also be available to the Philippines, subject, however, to a request from the Government and a commitment to repay any development loans approved.

In the past, there has been a poor record of repayment for assistance in renewable energy programmes. To be successful, therefore, future loans would need to be applied to the commercial sectors or through the major energy supply agencies such as NPC and the Philippines National Oil Company. Biomass energy development programmes in the sugar-cane and rice industries are highly appropriate for such concessional financing. Similarly, support for a viable energy-equipment industry would be both beneficial to the nation and sufficiently productive to ensure repayment of development loans.

The Government would on-lend concessional finance through the Development Bank of the Philippines to activities identified by the pre-investment sector studies of the aid agencies. Areas requiring financial support would include: private sector development support; manpower development and training facilities; manufacturing and supply industry development; and commercial project loan financing.

C. Mechanisms for international agency support

Since mechanisms to mobilize support for development of an international biomass programme were to be considered by the UNIDO Symposium, only a brief outline of areas in which aid and development loans may be used to support government initiatives in the Philippines is presented here.

1. Technical assistance programme

Grant aid could be used to promote biomass initiatives with such aims as the following:

(a) To support DOE in preparing submissions for development bank loans for the biomass energy sector, particularly to accelerate development of a strong equipment-manufacturing and technology transfer industry, and to promote use of co-generation the major agroprocessing industries;

(b) To formulate and fund institutional support programmes and to strengthen government and private agencies in the biomass energy sector, that is, in resource and market definition, database development, project planning techniques, project implementation capabilities, strengthening of the ANEC programme and training and skills development;

(c) To define technology demonstration programmes in key biomass energy areas, and to identify appropriate technology, funding sources and implementation agencies;

(d) To establish manpower development programmes for government departments, non-governmental organizations and private-sector agencies.

2. Development bank loan finance

In developing a proposal for a sectoral loan to promote and accelerate the introduction of biomass energy resources in key industrial and domestic areas, funding support could be considered for the following:

(a) Equipment manufacturing and supply industries;

(b) Suppliers of competitive improved domestic stoves;

(c) Concessional capital for major project development (sugar, rice, timber and coconut industries);

(d) Independent power production projects based on biomass fuels (high-efficiency dendrothermal project).

Development loans must be requested by the Government, and they are released through the Development Bank of the Philippines. This route requires the real commitment of the Government to the biomass energy sector, as the sectoral loan must be repaid at the prevailing agency rates. Therefore, there must be an acceptance that users and developers of biomass energy resources will be able to generate commercial returns, and thus be in a position to repay the loans. Since the above-mentioned areas could meet those commercial criteria, support should be given to the Government to prepare a loan proposal for a biomass development programme.

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