Study of Biomass As an Energy Source and Technical Options for Greenhouse Gas Emission Reduction: The Philippine Case

by

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I. National Energy Consumption Profile, 1995

The total energy consumption in the Philippines in 1995 was estimated to be about 32 million tons of oil equivalent (MTOE) of which biomass amounted to about 11.5 MTOE, or 35% of the total. Most of the biomass consumption (about 69 percent) comes from the residential sector, with cookstoves as the major end user.

Historically, the Philippines has been heavily dependent on imported oil for its energy needs. In recent years, the Philippine Government started to take measures to decrease the country's dependence on oil by developing indigenous energy resources. With the country's recently introduced programme towards diversification, the total energy requirement is projected to increase at an average rate of 6.6% per annum, over the period 1996-2025.

A study by the Regional Wood Energy Development Programme (RWEDP) of the FAO estimated that the consumption of woodfuels in the Philippines is only about 25.84% of their sustainable supply from traditional sources. Also, large amounts of agricultural residues generated annually remain unutilized. Thus, the present supply of biomass fuels can potentially provide a much large share of the total national energy requirements.

Biomass can provide further energy service in the Philippines through end-use efficiency improvement, use of agricultural residues which is currently disposed of by dumping or burning and the energy tree plantation in degraded lands.

II. BIOMASS UTILIZATION PATTERN, 1995

Table 1 shows that a large quantity of biomass was consumed by the residential sector in 1995. Cooking stoves consumed over 18 million tons (MT) of biomass fuels. Fuelwood and agricultural residues used for household energy amounted to 87% and 12% of the total residential consumption, respectively. Animal manure still had a meager share as compared to other biomass resources used in the residential sector.

In the commercial and industrial sector, about 1.0 MT of fuelwood, 7.4 MT crop residues and 11 thousand tons (kT) of animal waste were consumed. Furnaces consumed about 0.2 MT of fuelwood and 0.5 MT of crop residues, while boilers utilized 0.7 MT wood and woodwastes and 6.9 MT of crop residues which comes mostly from bagasse. In addition, about 0.6 MT of biomass fuels were used in dryers.

Table 1: Biomass Consumption by End-Use, 1995

Resource	Industrial/Commercial Sectors		Residential Sector	
	End-use Type	Ton/Year	End-use Type	Ton/Year
Wood Fuelwood Woodwaste	Boiler	712,292	Cooking stoves	14,557,024
	Cooking stove	13,916		
	Drier	42,722		
	Other Techs	3,413		
	Furnace/Kiln	239,642		
Total		**1,011,985**		**14,557,024**
Coconut husk with shell	Cooking stove	108	Cooking stoves	220,096
	Driers	10,114		
	Furnaces/Kiln	700		
	Other Techs	426		
Total		**11,348**		**220,096**
Coconut Fronds	Cooking stove	1,579	Cooking stoves	1,100,482
	Drying	2,780		
	Furnace/Kiln	410		
	Other	412		
Total		**5,181**		**1,100,482**
Coconut shells	Boilers	200,604	Cooking stoves	770,337
	Cooking stove	181		
	Drier	605		
	Furnace/Kiln	38,208		
	Gasifier	847		
	Other Techs	78		
Total		240,523		770,337
Coconut husks	Drier	509,113	Cooking stoves	110,048
	Furnace	7,467		
	Other Techs	63		
Total		**516,643**		**110,048**
Bagasse	Boiler	5,969,434		
	Cooking stove	629		
	Furnace/Kiln	17,582		
	Other Techs	2		
Total		**5,987,647**		**0**
Charcoal	Boiler	24	Cooking stoves	300,317
	Cooking stove	4,323	Water heating device	200,211
	Drier	53	Others	192,511
	Furnace/Kiln	9,072	Flat iron	77,004
	Gasifier	586		
	Other Techs	165,546		
Total		**179,604**		**770,043**
Ricehull	Boiler	6,824	Cooking stove	1,100,482
	Cooking stove	1,473		
	Drier	16,085		
	Furnace	399,985		
	Other Techs	7,774		
Total		**432,141**		**1,100,482**
Animal Manure	Biogas	10,692	Cooking stove	69,548
			Flat Iron	7
			Lighting	1
Total		**10,962**		**69,556**

On the other hand, **Figure 1** summarizes the sectoral breakdown of biomass utilization in the country in 1995. The household use of biomass accounted for about 68 percent of the total biomass consumption while the combined uses of industrial and commercial sectors registered about 32 percent of the total biomass utilization.

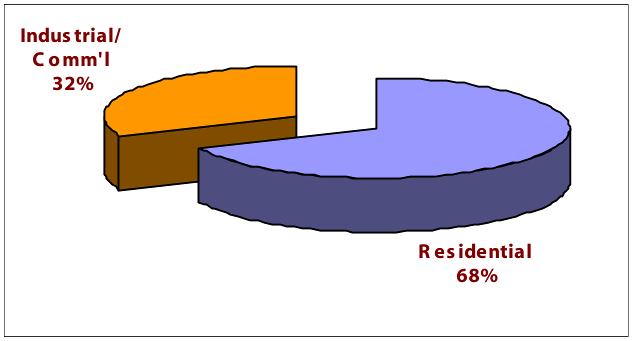

Figure 1. Biomass Utilization by Sector, 1995

Furthermore, **Table 2** shows the total emission of the selected greenhouse gas emissions associated with the utilization of biomass in 1995. Specifically, about 29.5 MT of carbon dioxide and 10.5 MT of carbon monoxide are released annually through the use of biomass in the country. The same usage also contributed to the annual releases of 132 kilotonnes (kT) of methane, 350 kT of total suspended particles, 44 kT of sulfur oxides, and 36 kT of nitrogen oxides in the Philippines.

Table 2. Greenhouse Gas Emissions from Biomass (In Thousand Tons), 1995

Type of Fuel	CO2	CO	CH4	TSP	SOX	NOX
Fuelwood	17,713.1	10,118.3	99.9	120.6	6.9	22.2
Agri-residues	9,669.5	214.6	25.9	216.3	37.1	11.3
Animal Waste	60.2	-	-	-	-	-
Charcoal	2,118.6	173.1	6.4	13.3	0.5	2.8
Total	29,561.5	10,506.0	132.2	350.2	44.4	36.2

III. EMERGING BIOMASS ENERGY TECHNOLOGIES

Both local and foreign efforts have contributed in the development of new and innovative biomass energy technologies which can potentially reduce greenhouse gas emissions and further increase the supply base of biomass resources.

Biomass Combustion

Combustion of biomass, which currently accounts for about 14% of the global total energy consumption, is likely to assume a much greater importance in the future as the world tries to mitigate the threat of climate change. Currently, almost all developing countries have some form of improved cookstove programme.

Practically all biomass-based electricity generation plants employ steam turbine systems. Such electricity generation is established in developed countries, where relatively cheap, waste biomass is available. Most systems are based on low-pressure boilers (about 20-25 bar) with efficiencies slightly below 20%. Modern biomass powered high pressure (60-100 bar) boiler-turbine systems produce electricity with efficiencies approaching 32%.

Thermal energy, produced by burning biomass and other low grade fuels, can be used for small-scale power generation using an external combustion engine, such as the Stirling Engine. This may be of great interest for rural applications, since there is potential for higher efficiencies than those using gasifier-engine or steam-based power plants of similar capacity.

Although historically disappointing, the technology now appears to be improving. Based on studies in Denmark, the overall electricity generation efficiency of biomass powered stirling engines with capacities of 36-150 kW could reach 21-26%. Some field units are currently being tested in New Zealand and this new generation of Stirling Engines may be considered for applications in the developing countries in the near future.

Cogeneration is the process of producing two useful forms of energy, normally electricity and heat, using the same fuels source. The process is well established in industries such as pulp and paper, sugar mills etc. Cogeneration is currently being practiced in sugar mills worldwide to meet in-house demand for steam and electricity, typically by using low-pressure boiler-steam turbine systems. Through the use of high-pressure systems, mills can produce substantial surplus electricity which could be sold to the grid.

In the Philippines, steam and power generation are the major uses of biomass in the industrial sector. They mainly comprise industries producing biomass wastes that can be used as fuel such as sugar processing, logging/wood products, and paper processing.

Biomass Gasification

Gasification technology is more than a century old. After World War II, interest in gasification technology practically disappeared, as oil became a cheap and convenient energy source. The energy crisis in 1973 triggered renewed interest, and a number of institutes and organizations built and tested/operated gasifier systems, mostly based on earlier designs.

Over the last 10 years, interest in large-scale biomass gasification for power generation has been growing. Efficiencies of over 40% are predicted for such plants. For capacities lower than 5-10 MWe, catalytic gas cleaning and low-tar gasifier designs may make a new generation of such gasifier feasible.

Small-scale gasification has been shown to be viable in the Philippines. Small-scale gasifiers, designed by the Department of Science and Technology are being used for small-scale pottery and brick-making projects and drying of paddy, fish and paper mache. The technology is not widely adopted due to lack of reliability in the absence of trained technicians, low cost of crude oil which makes gasification economically unattractive and lack of sustained promotion campaigns outlining the benefits.

Biomass Carbonization

Charcoal is used for domestic cooking and other applications. Charcoal making from agriresidues is gaining many acceptances. These residues, if left unutilized, often cause environmental problems. Wide range of devices which were developed for carbonizing agricultural and other residues have found limited acceptance so far.

Recent developments in biomass carbonization include generating energy from the waste gases produced during batch carbonization. The process improves both the overall process energy efficiency and the environment. Another development is torrefaction, a low temperature carbonization process that produces a substitute product for conventional charcoal in some applications. A new technique developed in Hawaii, USA is reported to yield charcoal at 42% to 62% of the original weight, compared to about 15-30% for conventional carbonization.

The University of the Philippines College of Engineering (UPCE studied a pyrolytic converter in the late 1980s with the primary objective of demonstrating the viability of a small-scale pyrolytic converter using rice hull. The result of the test runs showed that pyrolysis of rice hull is difficult but feasible.

Biomass Densification

Depending on the type of equipment used, densification can be categorized into four main types, namely: piston press densification, screw press densification, roll press densification, and pelletizing. Products from the first three types of densifications are large compared to pellets, and are normally called briquettes.

Densification involves compressing the raw material, which causes two problems; high electricity consumption by the driving motor; and wear of machine parts. Two recent developments for reducing wear and energy consumption of densification machines include the preheating to soften the raw material just before its compaction in briquetting machines and the use of a small amount of a thermoplastic material both to lubricate the die of pelleting presses and to improve calorific value of the densified product.

Efforts are also under way to apply advanced surface coating to the screw of briquetting machines that can dramatically increase their life by reducing wear.

Biogas Production

Biogas technology is already considered a commercial venture in the Philippines. Even though a number of installations are operating successfully, however, the use of biogas is not widespread. This is due to lack of information and technical know-how and high initial investment costs.

Table 3 shows an assessment of the level of development of various biomass energy conversion technologies in the Philippines.

Table 3. Assessment of Biomass Energy Technologies in the Philippines, 1995

Technology	Resource	Applications	Stage of Development				
			L	P	D	V	C
Improved Cookstove	Fuelwood	Household; Commercial establishments					■
	Ricehull					■	
Furnace Oven Boiler	Fuelwood	Heat, steam, power					■
	Charcoal	Process heat					■
	Bagasse	Heat, steam, power					■
	Cocoshell/husk	Heat, power					■
	Cocoshell/charcoal	Waste heat recovery		■		■	
	Ricehull	Heat				■	■
	Ricehull	Heat, power			■	■	
Gasification System	Charcoal	Process heat				■	
	Ricehull	Heat			■		
	Wood/woodwastes	Heat, power		■	■		
Biogas System	Animal manure	Household (heat)					■
	Animal manure; stillage	Industrial (heat)				■	■
		Industrial (power)				■	■
Pyrolysis Liquefaction	Woodwastes	Heat, power	■				
	Other biomass	Heat, power	■				
Densification	Ricehull Briquettes	Heat					■
Liquid fuels	Alcohol, coconut oil	Transport, power				■	

Legend: L – Laboratory; P- Pilot Stage; D- Demonstration; V- Commercially Ready; C – Commercially Available.

IV. ESTIMATION OF POTENTIAL SAVINGS FROM BIOMASS UTILIZATION

Energy from biomass normally commands the biggest share in the supply of energy in rural areas of developing countries, fuelwood often accounting for a major fraction of it. Most traditional technologies existing in the rural sector, have been identified as 'inefficient' and there is room for numerous minor and often major improvements in efficiency. The amount of biomass that can be saved through efficiency improvement can serve as a source of additional energy and can potentially substitute fossil fuels to reduce net GHG emission.

Table 4 shows the estimated biomass saving potential in the Philippines. The study reveals a saving potential of for fuelwood of about 8 MT. In addition, about 2.2 million tonnes of agricultural residues and 0.25 MT of charcoal can also be saved.

Table 4. Biomass Saving Potentials (In Million Tons), 1995

Sector	Fuelwood	Agriwastes	Charcoal
Residential			
Cookstoves	7.41	1.18	0.25
Industrial			
Ovens	0.03	-	-
Boilers	0.07	0.72	-
Furnaces	0.10	0.36	-
Total	**7.61**	**2.26**	**0.25**

The current situation is characterized by inefficient use of residues, with a certain amount disposed of wastefully. Fossil fuels, which could be substituted by residues, are burned, causing GHG emission. In the assumed improved situation, residues are used efficiently, and previously wasted residues are substituted for fossil fuels in a selected type of modern biomass energy system.

Efficiency improvement of existing biomass energy systems and deployment of modern biomass energy technologies can significantly reduce GHG emission, often at a negative cost. The emission mitigation potential is estimated by comparing a typical current situation with an assumed improved situation.

Table 5 gives the estimated energy generation potential and total GHG emission mitigation potential for rice husk in different modern energy systems in the Philippines. Most of these technology options offer a lower cost of energy generation than comparable fossil fuel based options.

Table 5. Impacts of Modern Biomass Technologies on Ricehusk Utilization

Technology Option	Energy Generation Potential	Mitigation Potential ('000 Tons CO2 Per Year)
1. Direct Combustion to Produce Steam	16,064 TJ	1,930.0
2. Direct Combustion (1 MW Power)	725 GWh	750.0
3. Direct Combustion (2.5 MW Power)	837 GWh	866.0
4. Direct Combustion (12 MW Power)	1,394 GWh	1,444.0
5. Direct Combustion (29 MW Power)	1,746 GWh	1,808.0
6. Gasification for Electricity Generation	498 GWh	359.0

V. CONCLUSIONS

Energy from biomass constitutes an important part of the total energy supply in the Philippines. The manner in which biomass is currently utilized for energy is, however, far from ideal and is characterized by gross inefficiency and pollution of the environment. Biomass fuels could provide a much more extensive energy service than at present if these were used efficiently. This could serve to reduce emission of greenhouse gases through substitution of fossil fuels.

The Philippines has an abundant supply of biomass resources, which could be a potentially significant source of energy. Some resources are already being exploited for energy, but considerable amounts are still treated as waste, and remain untapped.

Biomass consumption for energy in the Philippines was about 27 millions tones in 1995. Of this, nearly 70% was consumed by the residential sector. Cooking stoves and boilers are the major end-use applications of biomass fuels in the households and industrial sector respectively.