Biomass as Energy Source in the Philippines

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ABSTRACT

Total energy consumption in the Philippines in 1995 is estimated to be about 32.45 million tons oil equivalent (MTOE) in which share of biomass is about 11.5 MTOE or 35.45%. Shares of woodfuel, agricultural residues and charcoal in the total biomass use for energy were 57%, 39%, and 0.04%, respectively. Only about 20% of the potentially available biomass as a source of energy were used in 1995. Most of the biomass consumption (about 69%) were in the residential sector with cookstoves as the major end user.

1. INTRODUCTION

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 imported oil by developing indigenous energy resources, diversification of energy sources, and energy conservation, among others.

In 1995 alone, the country's consumption of imported energy amounted to 17 MTOE or about 52% of total energy consumption. Of this total, imported oil accounted for about 16 MTOE or 51%, while imported coal accounted for 0.5 MTOE or roughly 2%.

Indigenous energy on the other hand, accounted for close to 48% of energy consumption which is equivalent to 15.5 MTOE. Table 1 shows the details of primary energy consumption in the Philippines.

With the country's recently introduced program towards industrialization, the total energy requirement is projected to increase at an annual average rate of 6.6% over the period 1996-2025.

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Table 1. Primary energy consumption (million tons oil equivalent, MTOE).

Type	Million Tons Oil Equivalent	% Share
Indigenous energy	**15.5**	**47.6%**
Conventional	4.0	12.2% [(a)]
Oil	<0.1	negligible
Coal	<0.9	2.7%
Hydro	1.5	4.8%
Geothermal	1.5	4.7%
Non-conventional (mostly biomass)	11.5	35.4% [(b,c,d)]
Imported energy	**17.0**	**52.4%** [(e)]
Oil	16.5	50.7%
Coal	0.5	1.7%
Total energy	**32.5**	**100%**

Notes:
(a) Department of Energy [1]
(b) Household consumption estimates [2]
(c) Estimates for industrial sector [3]
(d) Other non-conventional energy resources include solar, wind, micro-hydro; their contribution is less than 1% of the total energy consumption.
(e) In the Philippines, heating value of crude oil is 0.1344 TOE per 0.16 m^3 and that of coal is 0.488 TOE per 1,000 kg.

2. BIOMASS RESOURCES IN THE PHILIPPINES

The Philippines is mainly an agricultural country. About 130 000 km^2 or 44% of its total area is devoted to agricultural crops like rice, corn, sugarcane and coconut. These crops generate residues during harvesting and processing and constitute a potentially important source of energy. Apart from crop residues, wood/woodwaste is also abundant and extensively used as fuel.

Estimates of biomass energy potential and current use are given in Table 2. The estimated annual generation of crop residues was based on crop production and established values of residue to crop ratios. As shown in Table 2, about 82%-97% of total annual bagasse production is used as fuel, making it the most widely used crop residue. Use of coconut residues and rice husk amount to 28% and 22% of annual production, respectively, while fuelwood consumption is reported to be less than 10% of the available supply. Other biomass such as sugar cane trash, rice straw and animal wastes do not contribute significantly to the national energy mix.

2.1 Wood and Woodwaste

Woodfuel and other woody biomass fuels are by far the most significant indigenous energy sources in the Philippines. Estimates of their contribution to the overall energy demand of the country vary. The 1992-2000 National Energy Plan of the Office of Energy Affairs (OEA, now

Table 2. Production and utilization of selected biomass fuels in the Philippines in 1994.

Biomass type	Estimated annu ıl generation (billion kg)	Amount used as fuel (billion kg)	% Used for energy	Source
Bagasse	6.82	5.58	82%	DOE [1]
		6.62	97%	NESCON [4]
		6.27	92%	EDUFI [5]
	8.15			RWEDP [6]
Cane trash	7.05	n.a.	n.a.	
	8.43			RWEDP [6]
Coconut husk/shell	6.44	1.81	28%	DOE [1]
		0.66	10%	NESCON [4]
	5.27			RWEDP [6]
Rice husk	2.11	0.46	22%	DOE [1]
	2.81			RWEDP [6]
Rice straw	18.52	n.a.	n.a.	
Fuelwood/ woodwaste	105.00	0.46	0%	DOE [1]
		1.75	2%	NESCON [4]
	89.27	23.05	26%	RWEDP [6]

Note: n.a. – not available

Department of Energy) estimated the contribution of non-conventional fuels including fuelwood at less than 13% of the total energy demand [7]. However, this estimate included only biomass used in large agro-industries that submit energy consumption reports to the OEA. On the other hand, a study done by Bensel and Remedio [8] reported the contribution of fuelwood alone to be 52% of total energy consumption with all forms of biomass contributing around 73% of the total.

In 1990, the Department of Energy and Natural Resources (DENR) estimated that the available fuelwood supply is only 23.2 billion kg while the Philippine Household Energy Strategy (PHES) study places annual sustainable biomass fuel yields at over 100 billion kg. Furthermore, Bensel and Remedio [8] reported that over 60% of the estimated sustainable supply come from non-forest lands, providing 90% and 70% of rural and urban woodfuel supply, respectively.

FAO meanwhile gave an estimated woodfuel consumption of 23 billion kg out of the potential available supply of 89.2 billion kg for 1994 and projected an increase in consumption to 30.3 billion kg and a decrease in the potential available supply to 71.2 billion kg in the year 2010 (Table 3).

2.2 Cane Trash and Bagasse

Cane trash and bagasse are produced during the harvesting and milling process of sugar cane, respectively. In 1994, total bagasse production amounted to about 7 billion kg, 82% to 97% of which was estimated to have been used for energy.

NCED-DOE [9] reported that sugarcane trash, which consists of sugarcane tops and leaves, is produced at the rate of 1.1 kg to 2.1 kg per m^2 of sugarcane depending of the variety and quality of growth, while Koopmans [10] gave an estimate of 0.1 kg to 0.3 kg per kg of cane.

In the sugar mills, bagasse is mostly used as a fuel to produce steam for power generation and for sugar processing. Cane trash on the other hand is mostly burned on the field and still not utilized due to its bulkiness and the high cost of collection/transportation.

Table 3. Potential supply and estimated consumption of woodfuel in 1994 and 2010 in the Philippines [6].

	1994			2010		
Consumption	Area 10^7 m^2	Mass million kg	Energy PJ	Area 10^7 m^2	Mass million kg	Energy PJ
Total woodfuels		23,051	346		30,329	455
Potential supply						
Sust. woodfuel from forest land	7,020	12,962	194	4,154	7,941	119
Sust. woodfuel from agricultural areas	21,153	30,819	462	25,409	39,177	588
Sust. woodfuel from other wooded lands	-	-	-	-	-	-
Waste woodfuel from deforestation	(254)	45,486	682	(134)	24,052	361
Total potential available woodfuels*	27,919	89,267	1,339	29,429	71,171	1,068
50% of crop processing residues	21,153	9,821	169	25,409	11,535	198
Total potential available biomass fuels		99,088	1,508		82,706	1,266

* Area = 78% of geographical land area

2.3 Rice Residues

Paddy is the main agricultural crop in the Philippines. In 1998, about 10 billion kg of paddy was harvested from approximately 35 thousand km² of land [11]. Some of the leading rice producing areas in the country are located in Central Luzon, Central Visayas, Southern Tagalog and Cagayan Valley.

Among the residues produced by the rice industry, only rice hull and straw can be used as fuel. Rice hull, the main by-product from rice milling, accounts for roughly 20% of paddy weight [4], while rice straw to paddy ratio ranges from 1.0 to 4.3 [11].

Based on the 1998 paddy production of some 10 billion kg, rice hull production can be estimated to be approximately 2 billion kg. Using straw to paddy ratio of 1.757 [9, 11], straw production in the Philippines can be estimated to be about 18 billion kg.

In estimating rice hull production, it should also be noted that the type of rice mill used affects its availability as a potential fuel. At present, three types of rice mills are widely used in the country, namely, *kiskisan*, *cono* and rubber roll mills. Of these, only in *cono* and rubber roll mills can rice hull be obtained since the by-product from *kiskisan* rice mill is a mixture of rice hull and bran which is mainly used in livestock feed. The approximate proportion of each type of rice mill presently used in the country is about 22% *cono*, 46% rubber roll and 31.5% *kiskisan*. In terms of capacity, although only about 68% of the total rice mills operating in the country, *cono* and rubber roll mills dominate the industry.

As an energy source, rice hull is used mainly in applications such as drying of paddy and other crops, as fuel in some households and restaurants using special cookstoves developed for the purpose, in bakeries and some candy establishments, fish smoking, brickmaking and salt making. Some rice mills also use rice hulls to generate steam and electricity for in-plant use.

On the other hand, rice straw is most commonly used as a fuel in pottery making.

2.4 Coconut Residues

For the past five years (1994-1998), the total area of coconut plantation in the Philippines averaged to about 30 000 km², annual production of nuts ranging from about 11.2 billion kg to about 12.2 billion kg. Potentially available biomass wastes from the coconut industry includes coconut husk, shell and fronds. Bhattacharya [12] reported the residues to crop ratio of coconut as 0.12 shell and 0.419 husk. Using this ratio, coconut shell and husk produced annually were about 1.34 billion kg to 1.46 billion kg and 4.7 billion kg to 5.1 billion kg, respectively. Coconut fronds are derived from the leaves, which are not normally cut, and thus are difficult to estimate.

These residues are largely utilized as fuel in the domestic and industrial sectors. Coconut shell is also converted into charcoal for cooking, ironing and water heating. As an industrial fuel, copra-drying facilities are practically the only major users of cocoshells and cocohusks. Based on the initial results of the DOE Non-conventional Energy System Census (NESCON), cocowastes are being used in ovens, kilns, cookstoves, and dryers as well as in gasifiers [4].

National consumption of coconut shell charcoal, raw coconut husk is about 520 million kg per year, 139 million kg per year and 450 million kg per year, respectively [13].

As cited in NCED-DOE [9], out of the total available supply, only 1.81 billion kg of coconut residues, i.e., only about 28% of total production, were consumed for energy in 1994.

2.5 Animal Wastes

A considerable number of livestock and poultry animals are raised annually all over the country. These include carabao, cattle, chicken, duck, goat and hog. Carabaos, goats and hogs are mostly raised in backyard scale, while cattle, chicken and ducks are mostly raised in commercial scale. Table 4 shows the estimated human and animal population in the country from 1994 to 1998.

Poultry manure specifically those coming from the commercial-scale level are intensively used in the country as feeds in the commercial fish production and as soil conditioner. Cattle and carabao manure, especially those raised in backyard-scale level, are sometimes composted by the farmers-owners and used as fertilizer.

Backyard-scale poultry and livestock production in the country in characterized as low and irregular in population, non-continuing and unconfined during the day. Considering these factors, only manure coming from the commercial-scale level of the industry are potentially available for viable modern energy utilization, e.g., biogas production. As shown in Table 5, the potential recoverable biogas from the country's livestock and poultry industry is about 35 PJ/year. The highest biogas potential can be derived from human waste.

3. BIOMASS ENERGY CONVERSION TECHNOLOGIES

3.1 Direct Combustion

In general, direct combustion devices consume practically all of biomass fuels. Different types of direct combustion systems are commercially available with application ranging from simple cooking to generation of power. An assessment of the level of development of various biomass energy conversion technologies is shown in Table 6.

Table 4. Human and animal population in the country (1994-1998) [11].

Animal	1994	1995	1996	1997	1998
Carabao	2,559,660	2,707,826	2,841,277	2,968,130	3,004,000
Cattle	1,936,049	2,020,651	2,128,455	2,266,280	2,266,000
Chicken	93,110,000	96,216,000	115,782,000	134,963,000	136,887,000
Duck	9,500,000	10,000,000	10,000,000	10,000,000	10,700,000
Goat	5,995,000	6,183,000	6,230,000	6,500,000	6,500,000
Human	66,391,000	67,839,000	69,282,000	70,724,000	-
Pig	8,226,530	8,941,190	9,025,950	9,752,180	10,210,000
Sheep	30,000	30,000	30,000	30,000	30,000

Table 5. Potential recoverable biogas from human and animal waste [14].

Animal	Number of heads	Dry matter production kg/head/day#	Fraction recoverable#	kg volatile solid per kg dry matter	Biogas yield	Potential recoverable biogas (PJ/year)
Carabao	2,707,826	2.526	0.5	0.796	0.43	8.45
Cattle	2,020,651	2.860	0.5	0.934	0.31	6.11
Chicken	96,216,000	0.043	1.0	0.465	0.28	3.93
Duck	10,000,000	0.051	1.0	0.392	0.56	0.82
Goat	6,183,000	0.552	0.33	0.598	0.49	2.41
Human	67,839,000	0.090	1.0	0.667	0.31	9.33
Pig	8,941,190	0.661	0.23	0.893	0.49	4.34
Sheep	30,000	0.329	0.33	0.912	0.49	0.01
Total potential recoverable biogas						35.40

* Note: Comparison is based on the 1995 population.
\# Bhattacharya [14]

Table 6. Assessment of biomass energy conversion technologies in the Philippines.

Technology	Resource	Applications	Development				
			L	P	D	V	C
Direct combustion systems							
Improved cookstoves	Fuelwood Ricehull	Households commercial establishment				X	
Furnaces, ovens, boilers	Fuelwood	Heat, steam, power					X
	Charcoal	Process heat					X
	Bagasse	Heat, steam, power					X
	Cocoshell/husk	Heat, power					X
	Cocoshell charcoal	Waste heat recovery		X		X	
	Ricehull	Heat				X	X
	Ricehull	Heat, power			X	X	
Gasification Systems	Charcoal	Process heat				X	
	Ricehull	Heat			X		
	Wood/woodwastes	Heat, Power		X	X		
Biogas system	Animal manure	Households (heat)			X		
	Animal manure, stillage	Industrial (heat)				X	X
		Industrial (power)				X	X
Pyrolysis, Liquefaction	Woodwastes	Heat, power	X				
	Other biomass	Heat, power	X				
Densification (briquetting)	Ricehull	Heat					X
Liquid fuels	Alcohol, coconut oil	Transport, power				X	

Stages of Development
L Technical concepts/Lab scale studies on-going
P Technical feasibility proven by pilot studies
D Technical feasibility proven by demonstration projects
V Proven competitive with conventional systems, ready for commercialization
C Technology already commercially available

Cookstoves

Cooking stoves use up most of the biomass resources in the rural areas of the country. The commonly used fuels for domestic cooking in the country are fuelwood/woodwaste and charcoal among others. The household stoves are usually simple systems such as the three-stone tripod or clay stoves.

Though inexpensive, these devices are very inefficient. The efficiency of stoves commonly used in the Philippines is presented in Table 7.

Steam and Power Generation

At present, steam and power generation consumes most of the biomass in the industrial sector. Based on the results of the NESCON survey conducted by the Department of Energy [3], the amount consumed is about 6.9 billion kg in 1995.

Users of biomass-fires boiler systems in the Philippines are mainly plants with large steam demands like those for sugar processing, logging/wood products, and paper processing.

Others

Application of biomass as fuel in the commercial sector include ovens/kilns - for drying, baking, brick making, ceramic making and pottery among others; and, furnaces/boilers - for steam generation.

Open biomass fires are also used for pig roasting, barbecue and grilling of banana, corn, etc., by small entrepreneurs in sidewalk stores and markets.

Table 7. Examples of cookstoves in the Philippines.

Resource	Cookstove	Efficiency (%)	Average efficiency, (%)
Fuelwood	Tripod	5-8	6.5
	Half-cylinder	8-11	9.5
	Full cylinder (cast aluminum)	no available data	-
	Lorena	22	22
Charcoal	Clay stove	18	18
	Bioflame stove	20	20
	Cement stove	21	21
	QB stove	37	37
	FPRDI	33	33
Sawdust	Clay stove	13	13
	Cement stove	8	8
	Kalanden	13	13
	Bioflame	13	13

3.2 Gasification and Pyrolysis

Small-scale gasification of biomass residues in the Philippines has already been proven to be techno-economically competitive against conventional alternatives. At present, small-scale gasifier-combustors designed and fabricated by the Department of Science and Technology (DOST) have been installed in different parts of the country and are used for small-scale pottery and brickmaking projects and drying of paddy, fish and paper mache. Also, the Industrial Technology Development Institute of the Department of Science and Technology (DOST-ITDI) is currently operating a 75 kW to 100 kW fluidized-bed gasifier pilot plant which uses different types of biomass fuels [9].

Even with the successful operation of the previously installed gasifiers, the technology is still not being widely adopted due to the following constraints: reliable operation of the system is not yet well established under local conditions due to low level of technical competence, economically unattractive due to lower price of crude oil and, absence of sustained information campaigns to promote the technology and its benefits among potential users.

Pyrolysis is till under demonstration stage in the country. 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 normally operated small-scale pyrolytic converter using rice hull. The results of the test runs showed that pyrolysis of rice hull is difficult but manageable [9].

3.3 Biogas Technology

Biogas technology is already considered to be a commercial technology in the Philippine industrial sector. However, even though a number of installations are operating successfully, use of biogas technology is still not widespread due to various reasons such as lack of information and technical know-how, and high cost of initial investment.

The most notable successful user of biogas technology in the Philippines is the Maya Farms wherein chicken and hog manure are used as raw materials. The farm utilizes the biogas for heat and power generation.

The existing installations which use biogas technology are mostly in the industrial and commercial sectors. Partial results of the NESCON Census showed that as of December 1990, 115 units of biogas installations were operational. Of these, 68 units were of floating type, 43 units were of fixed type and 4 units were of balloon type [9].

3.4 Alcohol and Alcohol Blends

Production of liquid fuels from biomass have been studied in the Philippines, and some blends have been demonstrated as ready for commercialization. One of the major constraints for their commercialization is the high current price of the raw material (e.g., coconut oil and alcohol.).

4. SECTORAL BIOMASS ENERGY CONSUMPTION

Biomass is extensively used as fuel in the Philippines both in the residential and industrial sectors. Its contribution in the country's total energy in 1995 was about 35%.

4.1 Residential Sector

Biomass consumption for 1995 in the residential sector was projected by ESMAP [2] to be about 24 billion kg with 81% of this total consumption coming from wood fuel, 11% from crop residues and about 7% from charcoal.

Based on the reported biomass consumption for 1995 by DOE, residential sector consumption amounted to only 18.7 billion kg with cooking as the major end-use. Amount of biomass fuel consumed in the residential sector are 77% woodfuel, about 19% agricultural residues, 4% charcoal and 0.4% animal manure in the form of biogas. Table 8 shows the use of biomass in the residential sector.

4.2 Industrial Sector

Table 9 shows the reported consumption of biomass in the industrial sector for 1995, which is about 8.4 billion kg.

Bagasse is the biggest biomass contributor in the industrial sector with 6 billion kg, which is about 71% of the total industrial consumption of biomass fuel. Woodfuel consumption was placed

Table 8. Use of biomass in the residential sector in the Philippines in 1995.

Resource	thousand kg/year	% of sector
Woodfuel	14,557,024	77.0
Crop residues	3,301,445	18.6
Charcoal	770,044	4.0
Animal waste (biogas)	69,555	0.4
Total	18,698,068	100

Table 9. Use of biomass for fuel in the industrial sector by application in 1995 [13].

Application	thousand kg per year	% of total
Steam and power generation	6,900,133	82.2%
Commercial applications	1,389,057	16.5%
Baking	84,623	1.0%
Commercial cooking	22,210	0.3%
Total	8,396,023	100.0%

at 1 billion kg, equivalent to around 12% of the total sectoral biomass consumption. Other residues such as coconut residues, rice hull, animal waste, etc., contributed about 1.2 billion kg or around 15%. Charcoal consumption on the other hand was reportedly about 180 million kg roughly 2% of total biomass consumption by the sector.

Application wise, biomass consumption in the industrial/commercial sector is used mainly for steam and power generation. In 1995, this application consumed about 6.9 billion kg of biomass, which are around 82% of the total (Table 9). This is followed by commercial applications like drying of crops (tobacco, rice, coconut meat, fish), ceramic processing, food manufacturing, metal works, brickmaking, etc. Biomass consumption for these applications is about 1.4 billion kg or equivalent to about 16.5% while baking and commercial cooking used only about 100 million kg of biomass which is about 1.3% of the total consumption.

5. SUMMARY OF TECHNOLOGY-WISE BIOMASS CONSUMPTION FOR ENERGY

Estimated biomass consumption by end-use of energy in 1995 is shown in Table 10. Out of the total biomass consumption of 27 billion kg, close to 19 billion kg or about 70% was consumed in the residential sector and 8.4 billion kg or 31% was consumed in the commercial/industrial sector.

Cookstove is the only major user of biomass in the residential sector. Based on the 1995 data, cookstove devices used about 14.6 billion kg of woodfuel, 2.2 billion kg of coconut residues, 1.1 billion kg of ricehull, and 800 million kg of charcoal per year.

In the industrial and commercial sectors, boilers are the biggest consumer of biomass fuel followed by furnaces and kilns. Biomass consumption of boilers in 1995 for electricity generation alone was about 600 million kg woodfuel, 5.2 billion kg bagasse, 100 million kg coconut shell and 3 million kg ricehull. Other major end-users of biomass in the commercial/industrial sectors are dryers, ovens/kilns and commercial cookstoves.

6. CONCLUSION

The Philippines has an abundant supply of biomass resources, which could be a potentially significant source of energy. Some resources are already being exploited as an energy source but considerable amounts are still treated as waste and remain untapped. Based on the year 1995, less than 20% of the potentailly available biomass was used as energy source.

Biomass consumption for energy in the Philippines was only about 27 billion kg in 1995. Out of this, about 19 billion kg or nearly 69% was consumed by the residential sector while more than 8 billion kg was consumed in the industrial/commercial sector.

Consumption in the residential and commercial sectors by types of biomass in billion kg are as follows: woodfuel contributes about 16; bagasse 6; rice hull 1.5; charcoal 1 and coconut residues 3. Contribution of animal wastes in the form of biogas in the total biomass consumption is very minimal.

Cookstoves and boilers are the major end-use devices of biomass fuels in the household and industrial sectors, respectively.

Table 10. Technology-wise biomass consumption in the Philippines (1995) [15].

Resource	Industrial and commercial sectors		thousand kg per year	Residential sectors	thousand kg per year
Wood/ woodwaste /fuelwood	Boilers	Power generation	622,586	Cookstoves	
		Drying	63,782	- Cooking	8,734,214
		Heating	21,811	- Water heating	1,746,843
		Rattan bending	4,113	- Others	4,075,967
	Cookstove	Cooking	13,916		
	Dryer	Coffee drying	179		
		Copra drying	2,914		
		Corn drying	19		
		Dryer	393		
		Flour drying	3		
		Fruit	605		
		Pork skin	605		
		Raw palm oil	605		
		Rubber	605		
		Tobacco	36,794		
	Other technology				
		Baking	461		
		Cooking	2,208		
		Handicraft	42		
		Pottery	628		
		Tobacco curing	74		
	Furnaces/kilns	Baking	72,936		
		Black smithing	112		
		Brick making	5,664		
		Candle making	6		
		Ceramics	1,331		
		Cooking	6,399		
		Paper drying	16		
		Fish smoking	29		
		Flue curing	103,204		
		Food processing	124		
		Heating	171		
		Kiln drying	11		
		Lime production	28,896		
		Multipurpose	9,004		
		Noodles making	141		
		Oil milling	207		
		Pancit making	44		
		Pot making	1,205		
		Salt making	1,956		
		Sugar milling	7,786		
		Water heating	400		
	Total		**1,011,085**	**Total**	**14,557,024**

Table 10. Technology-wise biomass consumption in the Philippines in 1995 (Cont.)

Resource	Industrial and commercial sectors		thousand kg per year	Residential sector	thousand kg per year
Cocohusk with shell	Cookstove	Cooking	108	Cookstove	220,096
	Dryer	Copra drying	9,480		
		Raw palm oil	634		
	Furnace	Baking	155		
		Ceramics	253		
		Cooking	13		
		Kiln drying	3		
		Pottery	276		
	Other technology	Cooking	426		
	Total		**11,348**	**Total**	**220.096**
Coconut fronds	Cookstove	Cooking	1,570	Cookstoves	1,100,482
	Dryer	Copra drying	1,790		
		Fish drying	70		
		Cane drying	920		
	Furnace	Baking	345		
		Candy making	25		
		Ceramic making	5		
		Cooking	14		
		Kiln drying	6		
		Pottery	16		
	Other technology	Cooking	412		
	Total		**5,181**	**Total**	**1,100,482**
Coconut shell	Boiler	Drying	25,350	Cookstoves	770,337
		Heating	40,560		
		Milling	30,000		
		Oil extraction	3,600		
		Pelletizer	426		
		Power generation	100,668		
	Cookstove	Cooking	181		
	Dryer	Copra drying	581		
		Corn drying	19		
		Cane drying	5		
	Furnace	Baking	1,064		
		Ceramic making	14		
		Cooking	102		
		Copra drying	1,501		
		Power generation	35,520		
		Water heating	7		
	Gasifier	Brick making	72		
		Power generation	775		
	Other technology	Cooking	78		
	Total		**240,523**	**Total**	**770,337**

Table 10. Technology-wise biomass consumption in the Philippines in 1995 (Cont.)

Resource	Industrial and commercial sectors		thousand kg per year	Residential sector	thousand kg per year
Coconut husk	Dryer	Batch drying	9	Cookstoves	110,048
		Copra drying	507,795		
		Fish drying	1,540		
		Cane drying	1,155		
	Furnace	Baking	1,162		
		Brick making	106		
		Cooking	323		
		Copra drying	7		
		Fish drying	427		
		Kiln drying	2		
		Oil milling	4,000		
		Pottery	57		
		Sugar making	1,379		
		Water heating	4		
	Other technology	Cooking	63		
	Total		**516,643**	**Total**	**110,048**
Bagasse	Boiler	Cooking	26,806		
		Heater	122,765		
		Power generation	5,193,585		
		Sugar milling	626,278		
	Cookstoves	Cooking	629		
	Furnace	Pottery	6		
		Sugar making	17,571		
		Vinegar making	5		
	Other technology	Baking	2		
	Total		**5,987,647**		
Charcoal	Boiler	Power generation	24	Cookstoves	
	Cookstoves	Cooking (Restaurants)	4,323	Cooking	300,317
	Dryer	Copra drying	53	Water heating	200,211
	Furnace	Bakery	8,359	Others	192,511
		Black smithing	384	Flat iron	77,004
		Cooking	70		
		Drying	163		
		Fish smoking	40		
		Flue curing	54		
		Heat brooder	2		
	Gasifier	Brick making	586		
	Other technology	Blacksmithing	415		
		Cooking	165,069		
		Heating iron	17		
		Pottery	45		
	Total		**179,604**	**Total**	**770,043**

Table 10. Technology-wise biomass consumption in the Philippines in 1995 (Cont.)

Resource	Industrial and commercial sectors		thousand kg per year	Residential secrtors	thousand kg per year
Rice hull	Boiler	Corn drying	3,465	Cookstove	1,100,482
		Palay drying	480		
		Power generation	2,879		
	Cookstove	Cooking	1,473		
	Dryer	Rubber sheet	203		
		Copra	89		
		Corn drying	23		
		Multipurpose drying	1,293		
		Palay drying	14,477		
	Furnace	Baking	602		
		Brick making	541		
		Candle making	30		
		Candy making	97		
		Cooking	5,721		
		Fish smoking	26		
		Flue curing	negligible		
		Heating	1,032		
		Lime production	363		
		Multipurpose drying	4,322		
		Oil making	36		
		Palay drying	382,602		
		Noodles making	45		
		Peanut brittle	14		
		Pottery making	31		
		Salt making	3,431		
		Water heater	1,092		
	Other technology				
		Briquetting	15		
		Cooking	428		
		Corn drying	334		
		Oil extraction	66		
		Pottery making	692		
		Salt making	6,142		
		Sugar making	97		
	Total		**432,141**	**Total**	**1,100,482**
Animal manure	Biogas	Copra drying	3	Cookstove	
		Palay drying	2	- Water heating	4
		Power generation	10,957	- Cooking	69,544
				Flat iron	7
				Electric bulb	1
	Total		**10,962**	**Total**	**69,556**

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