RENEWABLE BIOMASS FUEL AS "GREEN POWER" ALTERNATIVE FOR SUGARCANE MILLING IN THE PHILIPPINES*

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ABSTRACT: With rising energy costs for fossil fuels, new efforts are required to more fully develop biomass as an energy source for process heat and renewable energy power production in the Philippine sugar cane industry. The potential of three biomass resources (sugarcane trash, napier grass and fast growing trees) were examined as "Green Power" energy feedstock alternatives. Overall, the economic, environmental and social implications of utilizing cane residues appeared the most promising. The optimal management system that was identified to utilize the resource was to retain residues in the fields for soil nutrient and carbon management processes during the productive life of the sugar cane plantation and to harvest the residues for biofuel after the final ratoon harvest (typically once every 3-4 years). Sufficient cane trash is available following the final ratoon harvest to displace the 365,000 barrels of imported bunker oil used for processing energy in the sugar cane industry. The positive socio-economic impacts of a biofuel harvest in this application included the provision of 4000 seasonal jobs and the elimination of up to 14 million dollars in oil imports. Harvesting biofuels for process energy can also help develop the expertise necessary to create "green power" from co-generation in the future if investments are made in new boiler technology. In this application, napier grass appears to be a promising new incremental source of biomass. Its cost of production was projected to be only 7% higher than the cost of cane trash harvesting, mainly due to land lease costs for the crop. The main concerns with fast growing trees are the long period farmers have to wait prior to receiving an economic return, and that wood fuel prices may rise significantly due to competing end use applications in the densely populated Philippines.

Keywords: energy, sugar cane residue, napier grass, fast growing trees, milling

1 INTRODUCTION

Sugar processing is an energy intensive process with large amounts of heat required to evaporate water from cane juice. About 87% of the total energy use for sugarcane milling comes from bagasse, a byproduct of the milling process [1]. Sugar mills that have 3 interrelated factories: raw sugar, refineries and distilleries, have an inadequate supply of bagasse and traditionally rely on bunker oil as a supplementary energy source. Approximately, 5.9% of energy used in sugar processing is provided by 365, 000 barrels of imported bunker oil. At $40 US per barrel of oil, this represents a cash outflow of 14.6 million US dollar from the Philippines. The use of bunker oil is attributed to the low average thermal efficiency of most Philippine mill boilers (about 62.5%) as the technology for high pressure/temperature boilers was not available when most of the existing boilers were constructed.

The sugar cane industry also has the potential to generate electricity for the Philippines. Estimates of potential electric power co-generation are as high as 396 MW nationwide (1,386 GWh)[8]. At least 60-90 MW of bagasse co-generated power is available as an energy source [5]. Energy audits of 15 (out of 17) mills belonging to the Philippine Sugar Millers Association Inc. (PSMAI) showed that they were buying 18 GWh of electricity every season, which is equivalent to about 10% of their total power requirement [4]. The installation of high efficiency boilers for electrical co-generation would directly benefit many sugar mills [3]. Difficulties of adopting cogeneration systems are explained in Table 1.

Table 1: Challenges for exploiting power co-generation in the sugar industry

Difficulties	Options
Old age of equipment	• boiler retubing and rehabilitation • boiler replacement or addition using low-to-medium pressure boilers or high pressure boilers
Planter-miller cane sharing system is fixed at 60-70:30-40	Adopt the alternative cane purchase system for the Philippine Sugar Industry [2]
Poor maintenance and conservative operating practices	Adopt comprehensive technology transfer for power plant operation and specific knowledge of the biomass fired energy plant.
Large financial outlay for installing co-generation facilities: P343 M for 10.7 MW and P1,351 M for 43.0 MW	• Internally generate funds by issuing new equity shares • Debt financing • Leasing • Joint ventures • Build-operate-transfer (BOT) scheme and its variants

2. THE GREEN ENERGY SUPPLY SYSTEM OPTIONS

Efficient biomass supply systems need to be developed that are environmentally and socially acceptable for creating a green energy supply for heat and electricity production in the industry. It is "green power", because the CO_2 released during combustion is recycled back through crop photosynthesis of the standing biomass in the agricultural landscape. In this study, we assessed three biomass resources as potential feedstocks for developing this opportunity:

- Sugarcane trash
- High yielding perennial grass, i.e. Napier Grass
- Fast growing trees

USE OF BALED SUGARCANE TRASH

A literature survey of sugar cane residue collection found residue levels of 10-25 tonne per ha [9] and about 70% of the material to be recoverable. The trash yield to tonnage ratio can reach 20% for excessively leafy canes, with an average estimate of 15%.In the Philippines, only one mill has been practicing cane residue recovery for energy and has been for more than 10 years. At Hacienda Luisita on the island of Luzon, 8.6 tonnes/ha (representing 68.8% recovery) was found to be harvested.

The recoverable sugarcane trash in the Philippines is estimated to be: 1.488, 2.229 and 2.973 million tonnes for low, average, and high estimates respectively. However, we believe the most resource efficient management practice is to only harvest the residues after the final ratoon crop (Table 2). Sugarcane trash removal in between ratoon cycles can have detrimental effects on cane growth and soil fertility maintenance. The following factors need to be considered when removing sugarcane trash:

(1) Damage to ratoons by the collection equipment. Residue collection equipment can cause damage by wheel slippage, compaction, or wheel penetration into moist soil.

(2) Soil compaction and increased tillage requirements with increased infield traffic.

(3) Influence on soil water retention, evaporation, infiltration, and drainage properties.

(4) Susceptibility of the unprotected soil surface to wind or water erosion and effects on water relations. Mulch from cane trash protects the soil surface from splash, runoff and wind erosion and reduces evapotranspiration. With the presence of mulch, the infiltration rate of the soil is greater, minimizing runoff.

(5) Soil fertility impacts: The respective concentrations of N, P and K in the cane residue as about 0.3, 0.05 and 0.50% dry weight basis (i.e. for a 15 tonne/ha yield, the losses are 45, 7.5 and 75 kg/ha of N, P and K, respectively)[9]. However the nitrogen content lost by removing the cane trash does not represent the full fertility value of the residue. Patriquin (2001) estimated that cane trash farming increases nitrogen content of the soil by 50 to 200 kg/ha through asymbiotic nitrogen-fixation.

(6) Control of weeds, diseases, insects and other pests. Preharvest burning ordinarily kills off borer insects and reduces the rat population. Without burning, pest populations could increase.

(7) Long term deterioration of physical, chemical and biological properties of soils with less organic matter being returned annually to the soil.

Thus the best residue recovery option appears to be to collect the trash only after the last ratoon crop of a three or four year cycle. Trash remaining in the field following the final ratoon crop prior to land conversion presents a problem for farmers where burning is the most common means of disposal. Assuming harvesting occurs one year in three, the tonnage produced would reach 496,000 tonnes of cane residues/year under low estimate or about 743,000 tonnes per year for average estimates. The fuel value of sugarcane trash at low, average, high recovery estimates and tonnes canes that can be milled indicate that sugarcane trash can totally provide the estimated 13% bagasse deficit in milling.

Burning the trash in the field is the most common disposal practice on sugarcane farms, but some farmers mulch their cane trash for the ratoon crops. At Hacienda Luisita, (Tarlac, Philippines) who have ownership and control of the hacienda, green harvest practices to bale sugarcane trash and use it as biofuel for boilers has been done for more than a decade now. Their experiences showed that baled trash can be economically used as a biofuel.

Table 2: Fuel energy value sugarcane trash and tonnes canes that can be milled of its "green power."

Tonnes of Recoverable Canes Residues (1)	Fuel Value MLOE	Million Tonne Cane to be milled	% of Total Canes (2)
Low: 496, 000	100.0	2.0	11
Ave: 763, 000	154.2	3.05	17
High: 991, 000	200.2	3.96	22

*Technical coefficients used:
1 tonne sugarcane trash = 1.855 BFOE = 136 litres oil
sugarcane residue = 80% relative efficiency of bunker oil
1 tonne sugarcane residue= 1.855 x 136 x 0.80 = 202 LOE
Milling canes require 50.42 LOE/TC [1].
MLOE = Million Litres Oil Equivalent;
BFOE = Barrel Fuel Oil Equivalent

(1) Estimated from 1.488, 2.229, 2.473 million tonnes of sugarcane residue at low, average, high yield respectively [6]. Cane residue baling on the second ratoon only (on every 3 years).

(2) Tonnage yield (ave. for the last 3 years). 18.0 million tonnes.

From the NPK ratio of sugarcane residue, a value of about P143/tonne of trash can be estimated using the price of commercial fertilizer as a reference point. This is also the lowest estimated purchase price. By selling the trash harvest, farmers would save the costs associated with burning (removing trash from edges and fireguards). Considering the purchase price of baled trash and the additional baling/hauling expenses, the viability of baled sugarcane trash for COGEN remains an issue.

There are 3 cost items that should be considered in using baled-trash, namely:

trash purchase	P 143/tonne
collection/baling/hauling	P 905/tonne (Based on Hacienda Luisita experience)
temporary storage	P 200/tonne
TOTAL	P 1, 248/tonne

The use of sugarcane trash as a biofuel can provide financial benefits to the plant owners and investors. Moreover, the positive features can be appreciated in both the rural and national economy. It was found it could employ 4142 (low trash yield), 6214 (average), and 8285 (high) rural workers for a 5-month period [6]. For the Philippine trade balance, significant savings could be achieved by reducing the importation of bunker oil. Estimated savings ranged from $14.5 million US (low trash yield), $21.8 (average) and $29 million (high yield).

PRODUCTION OF HIGH YIELDING PERENNIAL GRASSES (I.E. NAPIER GRASS)

Napier grass (Pennisetum purpureum) is a very tall grass similar to sugar cane and energy cane and well suited to tropical environments. Grown in fertile soils and adequately fertilized, it can produce a large amount of biomass and is easily planted from stem cuttings. Like sugarcane, it can be ratooned after harvesting. Adapted cultivars can be maintained for 5-10 year production cycles. Some of the outstanding features of perennial high yielding warm season grasses like napiergrass and guineagrass as biomass crops are: high productivity, good water use efficiency, low P and K requirements, potential for use of Biological Nitrogen Fixing (BNF) varieties, stand longevity and better adaptation to marginal and erodible soils than sugar cane.

Research and development on the adaptability and selection of napier cultivars for biofuel is necessary for sustaining biomass supply in COGEN power plant projects. An economic analysis of napier production for biofuel revealed that the total cost as it reaches the mill yard is approximately P1339/tonne [6]. It costs almost the same to grow and harvest napier as to collect, bale, haul and store sugarcane trash as a biomass supply during the off-milling season. The largest additional cost is the land, as napier is a dedicated crop unlike sugarcane. Unfortunately, the Philippines has limited land available, as most of the agriculturally favorable areas have been cleared and are entirely used for crop production. The areas with the most potential for napier based biofuel production are hilly areas with marginal, eroded/degraded soils. Due to the remoteness of such sites, (50-100 km from the nearest mill) hauling and transport costs may be somewhat higher. Field drying to 26% moisture will also be somewhat more difficult than cane residues and is projected to take 1-2 weeks. The actual costs of production and logistics of the supply system need to be assessed under commercial conditions in the Philippines.

The main advantage of napier grass production is its potential to dramatically increase biofuel availability during the off milling season. Planting 50,000 ha of napier grass could provide one million ODT (approximately double the recoverable sugarcane residue resource). The development of napier grass would follow the utilization sugarcane trash as a substitute for bunker fuel (presumably the first step towards an off-season power generation industry). One outstanding question is the suitability of the napier grass as a feedstock for long term boiler operation, and concerns about clinker formation and fouling.

FAST GROWING FUEL WOOD TREE SPECIES

Despite the wood deficit in the Philippines, tree planting has not gained acceptance among farmers. Possible explanations include the long maturing period of wood tree species and the lack of a ready market for wood in communities where trees are to be planted. There also appears to be a lack of support services for tree improvement. The adoption of power co-generation in sugarcane milling would provide an additional market for fuelwood. Thus, planting or integrating fuelwood tree species into the existing agricultural landscape would offer the potential for increasing farmers' income. Tree cultivation is also compatible with environmental enhancement, protection and conservation measures in the rural areas.

Farm-level promotion of fuelwood tree species cultivation would require research in the following areas:

- Appropriate wood tree planting schemes
- Identification/selection of fast growing fuelwood tree species
- Provision of seeds/seedlings and initial tree-establishment techniques and subsequent care and maintenance
- Optimization of the logistics of fuelwood supply systems as the production could be quite disperse.

There are at least 2 schemes of planting and/or integrating wood tree species in the agricultural landscape, these include:

- Use of perimeter or boundary trees
- Planting trees on marginal lands

To encourage farmers to plant trees for biofuel, information must be provided about species of trees adapted to their specific farm situation and location. Appropriate species mixtures for perimeters/boundaries should be specified. Farmers dedicating areas entirely to fuelwood also require information about appropriate tree species. Multipurpose tree legume species appears advantageous and practical since these true species do not require N-fertilizer application to boost tree growth.

The price of fuelwood in the Philippines is rising with the continued deforestation of the nation. The average retail price for firewood was identified in the 1995 household survey to be P2,480/tonne (in the rural areas of the Western Visayas). Purchase of wood in shelterbelts or plantations will have to compete with firewood prices. For the very high volumes of fuelwood required to develop an off-season sugar milling industry the delivered cost will be higher than the relatively low cost materials the mill can currently procure for the initial firing of the boilers. Production of large volumes of wood will ultimately compete with firewood prices. A purchase price for fuelwood of P2000 tonne would be equal to 80% of the 1995 household energy survey price. Counting on the use of wood as a boiler fuel may be risky in the Philippines as the country has a high population density to create competing end use applications as well deforestation remains an ongoing problem.

3. COST COMPARISON OF BIOMASS ALTERNATIVES

A comparison of the fuel, production, and delivered costs are shown on Table 3. The price of the biomass resource is deemed to be economically attractive to mill owners if it is priced based on its fuel value equivalent to oil at $20/barrel (approximately 1/2 of current world oil market prices). There currently is no surplus bagasse resource available in the Philippines as it is already being traded as as a boiler fuel due to recent price increases in oil.

Table 3: Fuel value, cost of production and suggested purchase price of sugarcane bagasse, cane trash, napier grass and fuelwood.

Biomass	Fuel value per tonne (wet) based on bunker oil energy equivalent, (P)	Cost of Production (P)	Suggested Purchase price per delivered tonne (P)	HHV GJ/ tonne	Moisture Content (%)
Sugarcane bagasse	1,658	0	1,050	18	48-52
Sugarcane trash	2,489	1,048	1,650	18	26
Napier	2,489	1,339	1,650	18	26
Fuelwood	3,100	Varies	2,000	20	35

* The suggested purchase price for biofuels is based on an energy value equivalent to pricing oil at $20 USD per barrel. At the time of the analysis 52 peso=1 USD.

4. CONCLUSION

The Philippine sugar industry has lagged behind other nations in its ability to reduce its importation of fossil fuels for use in the sugar cane processing industry. This can be done through the installation of more efficient boilers, which would use the bagasse resource more efficiently. Alternatively, with a very small investment in field machinery, sugar cane mills could procure trash to eliminate expensive fuel imports. The potential also exists for sugar cane trash, napier grass and fuelwood to create reliable power generation (concurrently with modernization of sugar mills). This study indicated that all three biomass could be used as “green power” substitutes for power generation for sugarcane milling in the future. Further study is required on the suitability and biomass quality of the sugarcane trash and napier grass for sustained firing in current boilers being utilized by the industry.

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