HEAT AND POWER FROM EUCALYPTUS AND BAGASSE IN NICARAGUA: PART A: DESCRIPTION OF EXISTING INITIATIVES

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ABSTRACT: This paper describes and compares the plans of two Nicaraguan sugarmills to sell power to the national grid, during the sugarcane harvesting season with bagasse as its principal fuel and outside this season with eucalyptus grown as dedicated energy crop. The environmental, micro- and macro-economic impacts of this project is investigated too and described in part B of this paper elsewhere in the proceedings.[1]
Power generation based on dedicated energy crops is not only an attractive option for the future. Looking at the ongoing negotiations for power sale of the sugarmills to the national grid, it appears to be a suitable and competitive alternative in Nicaragua at this moment.

1. INTRODUCTION

In the past, against the background of low energy and high sugar prices, the combustion of bagasse (a by-product of the process of producing sugar out of sugarcane) was seen as a method of getting rid of a residue. With the collapse of the world sugarmarket and the two energy crises, bagasse was seen more and more as a usefull by-product to generate heat and power. The sugarcane industry has historically been using bagasse for generation of heat and power to fulfill its own energy demand.
In Nicaragua, at this moment, there is a potential for the sugarmills to extend their power production and sell power to the national grid, both during and outside the sugarcane crushing season. A potential off-season fuel is eucalyptus from dedicated energy plantations. Beside environmental advantages this use of idle capacity is likely to generate significant socio-economic benefits as well.
Part B of this paper (elsewhere in the proceedings) compares the financial, macro-economic and environmental impacts of these initiatives with alternative ways of power generation in Nicaragua.[1]
The objective of this paper is to describe the existing plans of these sugarmills against the background of the power- and sugar-sector in Nicaragua.

2. THE NICARAGUAN POWER SECTOR

With 48% of the Nicaraguan population connected to the national grid, electricity production comprises 6% of the final energy consumption [1]. In 1995 the maximum load was 327 MW_e with a total installed capacity of 393 MW_e [2]. Figure 2 shows that about 60% of the electriciy is generated from oil derived fuels (mainly fuel oil). Imports of oil products in Nicaragua (26% of which is consumed in the power sector [2]) in 1995 constituted about 13% of total imports (or 25% of total export earnings) [2].

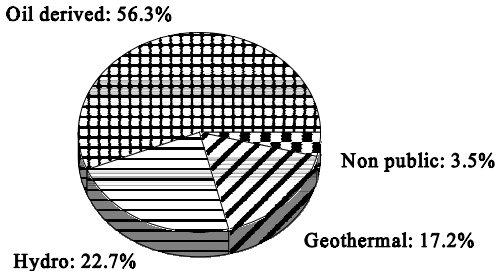

Figure 1. Energy use for power generation in Nicaragua in 1995 [1]

The Ministry of Energy of Nicaragua has estimated that because of the growth in electricity demand for next the 20 years, the installed capacity has to increase with a factor 2.3 to 2.7. [3]
At this moment, a new law to support private participation in power generation, is in the process of approval in Nicaragua. Private investments in the power sector are now slowly coming in. As a result of tendering procedures, contracts have been given to oil firing private companies of about 9 ¢/kWh [4]. Payback tariffs for supplier driven projects (without tendering) like the ones in the sugarmills are estimated at this moment at about 6.5 ¢/kWh, which isa big disadvantage for the latter party [5].

3. THE SUGAR INDUSTRY IN NICARAGUA

During the 80's, all sugar mills were nationalized by the Sandinista government. As a result of economic difficulties, production was very low during this period. In 1990 (re-)privatization of the mills was initiated, being concluded by 1993. Today, sugar cane is again one of the most important crops of Nicaragua, with seven sugar mills in operation and a total estimated production in 1996/97 of 4 million tonnes of sugar cane. The 44% of the produced sugar that was exported in 1995/1996, constituted about 6% of the total export [6, 7].
The sugarmills in Nicaragua are characterised by more or less self sufficient energy supply from their bagasse and by a harvesting season of about half a year maximum. The rest of the year, both the sugarmills and their power plants are not utilised.

[1]This study was initiated and co-financed under the "academic programme" of the Food and Agriculture Organisation of the United Nations (FAO).

4. INITIATIVES ON CHP GENERATION WITH BAGASSE AND WOOD

The San Antonio and the Victoria de Julio sugarmill have both launched plans to sell power to the national grid by increasing their power generation capacity during the harvest season and by extending power generation into the non-harvest season, thus becoming full power plants. In this period, eucalyptus (camaldulensis) from dedicated plantations will be the principal fuel.

4.1. The San Antonio sugarmill

The San Antonio sugarmill in Chichigalpa is the largest sugarmill of Nicaragua (Table 1). It started to operate in 1893 and has a history of step by step updating its technology. Negociations for a power supply contract for the present power extention plan are ongoing with the Nicarguan utility.

The first eucalyptus plantations were established in the area of the sugarcane plantations, at those soils that were not suitable for sugarcane. The newer ones were established in an area about 15 km north of the sugarcane area and at this moment the expansion is going on by renting soil within a distance of about 50 km from the sugarmill. Generally, the plantations are situated on either degraded soils or on soils that do not allow a profitable agricultural system. Principal technical parameters of the eucalyptus plantations are presented in Table 1.

The planting structure allows weeding by light tractors, which even under the low labour conditions in Nicaragua appears to be cheaper than manual weeding, because of its higher effectiveness. Recent try-outs with the use of herbicides in the first two years may reduce costs even further. Probably the optimal weeding control strategy will vary from site to site [9]. For more details on the whole production method we refer to part B of this paper elsewhere in the proceedings.

Part of the strategy to expand the wood supply to the sugarmill in the future, is the present attempt to establish a contract with the cooperatives of a nearby rural development project, named "Los Maribios". This project aims at the (environmental and economical) sustainable use of more or less degraded soils near the vulcanic area "Cordillera Los Maribios". Part of the activities is the establishment of small scale farm based wood plantations. The project, which is characterised by a strong farmer participation, initiated in 1989 and in 1996 already 2620 hectares of wood plantation were established (71% of which being eucalyptus) [14]. The San Antonio sugarmill is now offering to pay \$10 per m^3 (solid volume) of standing stock, provided that long term contracts are established.[10]

For the farmers of Los Maribios, probably the main questions to be answered are whether the alternative of supplying wood to the woodfuel market in Leon (which is the case at this moment) is financially more attractive and whether a dependency on a large sugarmill may cause problems for the still relatively fragile farmer cooperation system.

Figure 2 shows the San Antonio power plant as it is foreseen in its ultimate phase. More details on this system are presented in part B of this paper.

Table 1. Basic parameters for the existing CHP initiatives in the sugarmills San Antonio and Victoria de Julio[b].

		San Antonio[a]			Victoria de Julio[a]	
		'96/'97	'97/'98	>'99	'96/'98	>'99
Sugarcane flow	[kt/day]	10	11	13	5	7
Average sugarcane yield	[t_{wet}/ha.yr]	n.a.	n.a.	n.a.	70	n.a.
Established eucalyptus plantation	[ha]	1796[c]	2496[c]	> 3500[c]	3675	7354
Part of soils with wood owned by mill	[%]	72	n.a.	39	74	n.a.
Average eucalyptus yield	[t_{dry}/ha.yr]	-	-	12	5 - 11	n.a.
Operational cap. during season	[MW_e]	9	23.4	23.4	12	24
Surplus during harvest season	[MW_e]	0	10.2	10.2	4[d]	16
Operational cap. outside seasson	[MW_e]	0	15	15	12	36
Surplus outside harvest season	[MW_e]	0	0	12	0	31
Electric eff., LHV, gross	[%]	-	-	22	-	20
Average annual rainfall	[mm]	1352			1114	
Harvest rotation (total lifetime)	[year]	6 (24)			4-5 (20)	
Weed control		by hand, machine and herbicide			by hand	
Largest distance from mill	[km]	55			15	
Plant density	[plants/ha]	2200				
Genetic improvement		only seed selection from local seed orchard				
"Subsoil breaking"		applied				
Fertilization		not applied				
Irrigation		not applied				
Pesticides use		during establishment used agains red ants				
Harvest method		chainsaw				
Use of leafs and small branches		not harvested				
Air drying behaviour eucalyptus		Drying of trunks: in 1 month from 45 to 25 - 18% m.c.				
Chipping of wood		centrally at the power plant				

[a]References used for San Antonio are: [8-10]. For Victoria de Julio: [11-13].
[b]"n.a.": data not available at this moment; "-": not applicable.
[c]The Los Maribios area in 1996 contained 2620 of small scale farm based wood plantations.
[d]This power is not sold, but largely interchanged with power use of the irrigation system during the non-harvest season.

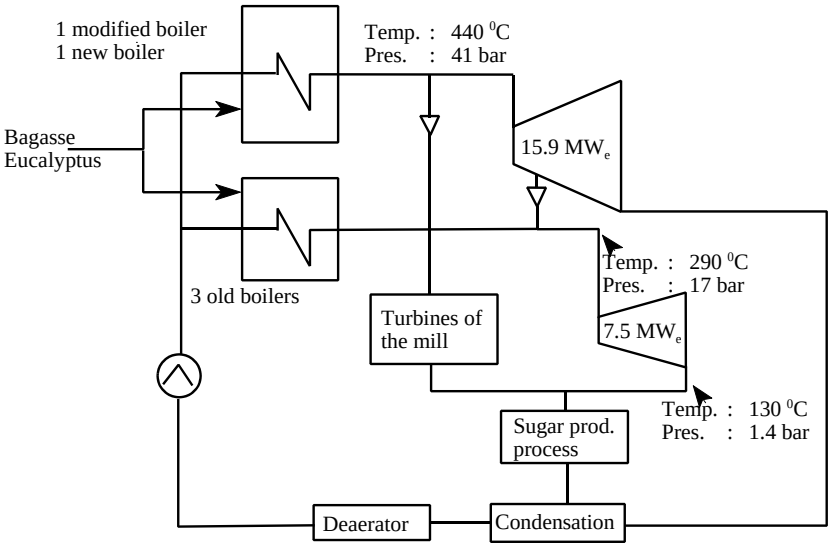

Figure 2. Design of the power plant after extentions at San Antonio. During the sugar season this whole system is used. Outside this season, eucalyptus will be fired only using the full capacity (without steam extraction) of the upper turbine.

4.2. The sugarmill "Victoria de Julio"

The Victoria de Julio sugarmill is the second largest sugarmill of Nicaragua, which started its operation in 1985. This sugarmill is a-typical in Central-America. The concept of electricity as a second product was already integrated in the original design of the plant (Figure 3). Further, the unique concept of the sugarcane plantations is that they are all irrigated by circular pivot systems (each with a radius of 500 m). An excellent logistical system has been created, consisting of the more than 180 circles with roads running in between them and the sugarmill in the middle [12]. Basic information on this sugarmill is presented in Table 1.

The eucalyptus plantations make use of the soil in between the circular sugarcane plantations. This means that about 20 ha can be used in each square (of 1 by 1 km) containing a circular pivot irrigation system. Beside this, soils that are not suitable for sugarcane, are used too (Table 1). Part of the soils have a tendency to tear during the dry season, which can cause damage to the root system of the trees. Further the upper layer is highly compacted. In spite of this, subsoil treatment, which allows the roots to penetrate into the soil easier, is not implemented at all sites here.

The planting of eucalyptus started aready in 1986, which means that some parts are already harvested twice (Table 2).

Table 2. First harvest results of two rotations at Victoria de Julio. Figures refer to harvested trunks only, being about 85% of the above-ground dry matter. [13].

Size of plantation harvested [ha]	Average yield [$tonne_{dry}$/ha.yr] of the first rotation (5 years)	Average yield [$tonne_{dry}$/ha.yr] of the second rotation (4 years)
4	5.4	8.0
14	6.2	9.0
19	7.1	10.5
15	7.1	10.6

Figure 3 shows the scheme of the Victoria de Julio sugarmill power plant. The two 12 MW_e turbines, on which the power sales are mainly based, are still not installed, although they have been available at the sugarmill for more than 8 years. The extension that is needed at this moment, thus mainly consists of the installation of these turbines and upgrading of the existing boiler system. One 12 MW_e low pressure condensing turbine will be placed in series with the existing three 4 MW_e turbines and generate power outside the harvesing season. The other 12 MW_e turbine is a high pressure extraction-condensing turbine which can be used for power generation whole year round, but which could also back-up the three 4 MW_e turbines as supply source of steam to the sugarmill. Because of the relatively low steam temperature, efficiencies will remain modest (Table 1).

4.3. Difference in power plants

Apart of the higher steam pressure and temperature there is another principal difference between the two CHP concepts. In these CHP plants, with only steam consumption during the sugar harvest season, there will always temporarily be a part of the system that is underutilised during. The sugarmills differ with respect to the location and time in the year of this underutilisation. With Victoria de Julio, the underutilisation is during the sugarcane harvest season and located in the 12 MW_e turbine parallel to the sugarmill (Figure 3). In the San Antonio sugarmill, this underutilisation is outside the harvest season and located in the boilers and in the high pressure part of the condensing-extraction turbine (having a higher capacity than the low pressure part). The consequence is that the net available electric capacity in Victoria de Julio is larger outside the harvest season, while for San Antonio this is the case during the harvest season. Including the power consumption of the sugarmills during the sugarcane season, in Victoria de Julio the variation during the year in potential exported power to the grid is much larger than in San Antonio, being a disadvantage for first, because constant capacity has a higher market value than variable capacity. Of course, this has to be weighed against the difference in investment costs.

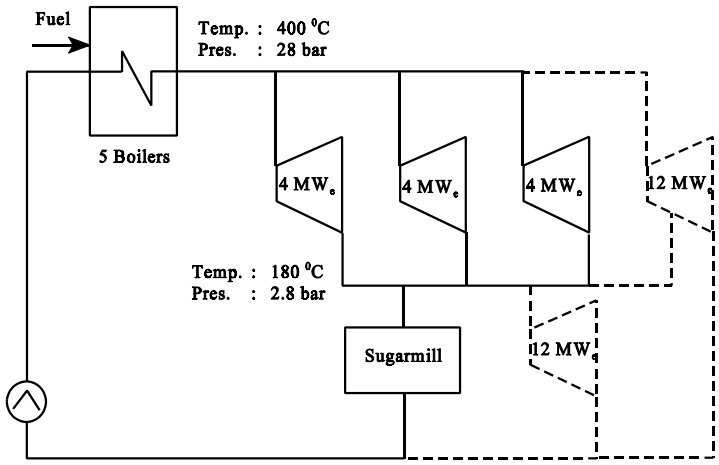

Figure 3. Scheme of the Victoria de Julio sugarmill; dotted lines indicate the extensions

5. PRESENT NON-TECHNICAL PROBLEMS

The largest showstopper for the development of the above discussed initiatives in Nicaragua at this moment is the property issue. Many present owners of land in Nicaragua are not shure whether in the near future previous owners will put a claim on their possessions. This causes great uncertainty and a bad investment climate.
Another reason for cautiousness within the sugar industry is the existing plan of the present liberal government to reduce import taxes on (a.o.) sugar. Because sugar industries all over the world are still heavily protected, with world market prices far below the sugar cost price, this could be a serious threat for the Nicaraguan sugar industry.

6. CONCLUSIONS

The context of the power and sugar sector in Nicaragua has led to initiatives of the sugarmills San Antonio and Victoria de Julio to supply power to the national grid both during and outside their sugar harvesting season. Outside the season the principal fuel will be eucalyptus, grown as a dedicated energy crop.
This way of power generation is likely to trigger mainly positive environmental impacts and a higher than usual national value added in the cost of electricity generation, leading to the creation of more employment.
Power generation based on dedicated energy crop is not only a future option, but looks competitive at this moment in the Nicaraguan sugarmills, for power supply contracts are about to be signed.

7. ACKNOWLEDGEMENTS

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