POWER GENERATION
FROM FUELWOOD BY THE NICARAGUAN SUGAR MILLS

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ABSTRACT

With new concept development for the sugar industry and with new power market opportunities, two sugar mills in Nicaragua initiated projects aimed at becoming power plants during the sugar cane off-season. Basically the idea is to use more efficient boilers and turbines, and generate power beyond the mill's needs fueled by bagasse during the sugar cane crushing season ,and by fuelwood from eucalyptus plantations during the sugar cane off season. The surplus power in both seasons will be sold to the public utility for grid distribution.

1. INTRODUCTION

Nicaragua, is one of the poorest countries in Latin America and very much dependent on non-sustainable biomass to satisfy its energy needs (Alves-Milho, 1997). According to the Nicaraguan Energy Institute - INE, the total primary energy supply in 1995 was about 1,9 Mtoe, 62% of which were biomass fuels. (INE,1996b)(Figure 1). Most of the biomass fuel is used as fuelwood (93%) by the domestic sector for cooking, and to a lesser extend by the industrial and commercial sector. Total consumption of fuelwood is estimated in 2.5 millions tons annually (20% mc). The remaining biomass sources used for energy are: bagasse (mainly at the sugar mills), rice husk, coffee parchment and other crops residues (Miranda, 1997).

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 sugar market and the two energy crises, bagasse was seen more and more as a useful by-product to generate heat and power. The sugarcane industry has historically been using bagasse for generation of heat and power only to fulfill its own energy demand.

The sugar mills in Nicaragua are characterized by a more or less self sufficient energy supply from their bagasse and by a harvesting season which can last for half a year maximum. The rest of the year, both the sugar mills and their power plants are not utilized. However, in Nicaragua, at this moment, there are two sugar mills developing their potential to extend their power production and to sell power to the national grid, both during and outside the sugarcane crushing season. An innovative approach of using fuelwood from dedicated energy plantations to fuel the boilers outside the sugar cane season looks very promising. The largest sugar mill in the country, San Antonio (located near the town of Chichigalpa) is upgrading its power generation efficiency. Their plan is to come in a two step approach to a power sale of about 15 MW_e (Broek 1997a). In this paper we will focus on the other sugar mill which has similar plans: Victoria de Julio, situated just 30 Km outside the capital Managua.

An detailed study is being developed at the moment by van den Broek (Broek., 1997b) in order to assess the possible advantages of this approach, which are:(I) increase in profitability of the sugar mills, (ii) increase the area under tree cultivation, (iii) increase new power capacity at lower cost, (iv) increase of employment opportunities, (v) import substitution of fossil fuels, and (vi) on a global basis reduce CO_2 emissions. Final results of this study are expected in 1998. However, some initial results are presented here.

2. THE NICARAGUAN POWER SECTOR

Since the creation of the national grid in 1958, the power sector in Nicaragua has been state owned. During the eighties, the period of the civil war and the USA trade embargo, the power capacity of the country remained around 330 MW_e (Miranda, 1997). Since the end of the Nicaraguan civil war in 1990, the economy has been slowly recovering and new policies are being defined in order to attract the private investment. At this moment, a new law to regulate private participation in power generation, is in the process of approval in Nicaragua.

With only 48% of the Nicaraguan population connected to the national grid, electricity production comprises 6% of the final energy consumption. In 1995 the maximum load was 327 MW_e with a total installed capacity of 393 MW_e (INE,1996c). However, because some plants were operating below their nominal capacity, the actual capacity was only 330 MW_e (INE,1996a). With an overall load factor of about 60%, the consumption of electrical energy was 1,630 GWh. Figure 2 shows that almost 60% of the electricity is generated from oil derived fuels (mainly fuel oil). Imports of oil and oil derived products in Nicaragua in 1995 constituted about 13% of total imports (or 25% of total export earnings) (FIDEG,1996). About 26% of this fuel is consumed in the power sector (INE,1996c).

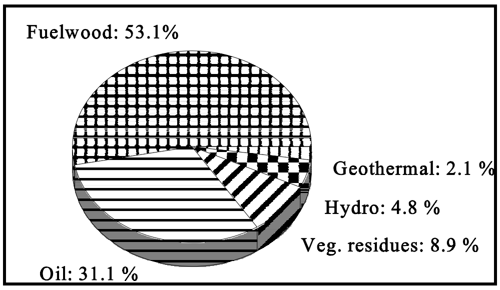

Figure 1. Primary energy supply in Nicaragua in 1995 (INE, 1996b)

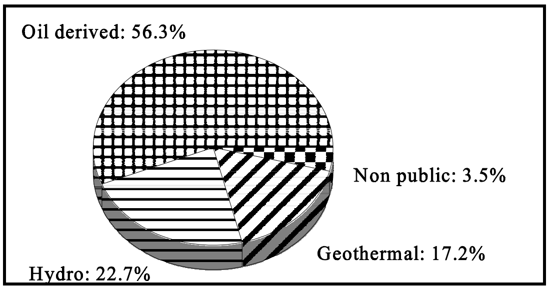

Figure 2. Energy use for power generation in Nicaragua in 1995 (INE, 1996b)

The Ministry of Energy of Nicaragua has estimated the electricity demand growth for the next 20 years between 5.4 and 6.1% annually. This means that the installed capacity towards 2015 has to increase with a factor 2.3 to 2.7. A fast solution to the Nicaraguan power crisis has been the import of expensive power from neighboring countries and a new 32 MW_e contract with a private company with a pay back tariff of 0.088 \$/kWh (Gonzalez,1997).

3. POWER GENERATION WITH BAGASSE AND FUELWOOD IN THE VICTORIA DE JULIO SUGAR MILL

The Victoria de Julio sugar mill is the second largest sugar mill of Nicaragua, and owned by AGROINSA, a private enterprise. It is situated about 30 km northeast of the capital Managua. Construction took place in the beginning of the 80's and operation started in 1985. This sugar mill is a-typical since the concept of electricity as a second product was integrated in its original design, by generating excess power during the harvest season and by extending power generation into the non-harvest season, thus becoming a full power plant. In this last period, Eucalyptus camaldulensis from dedicated plantations will be the principal fuel.

This plant was designed and built by the Cuban government and later donated to the Nicaraguan government. The unique concept of the sugarcane plantations is that they are settled up in a system which consist of squares of 100 hectares (1000 m x 1000 m). The sugar cane plantations are all irrigated by circular pivot systems with a radius of 500 m, which covers 80 hectares. The remaining areas not covered by the pivot system of about 20 hectares, are planted with eucalyptus. An excellent logistical system has been created, consisting of the more than 180 circles with roads running in between them and the sugar mill in the middle
(Detrinidad, 1996).

3.1. THE FUELWOOD SUPPLY

Besides the eucalyptus planted between the circular sugarcane plantations, also other soils that are not suitable for sugarcane, are used for the eucalyptus too. Today there are 3675 hectares of eucalyptus plantations already established, and the future need will be for about 7354 hectares. Expansion of the plantations will probably take place by acquiring new land in the neighborhood, and through contracts with local farmers to produce sustainable fuelwood.

A problem with the soils at Victoria de Julio is that they are vertisol, the type of soil that has a tendency to crack 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, has only been partly implemented here in the past. The planting of eucalyptus started in 1986, which means that some parts of the plantation are already harvested twice. Available yield figures are mentioned in Table 1.

Table 1. First harvest results of Victoria de Julio. Figures refer to the harvested trunks at 0% M.C.. About 15% of the dry matter in the form of small branches and leafs are left in the field and not included in these numbers (Coronel , 1997).

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
14	6.2	9
19	7.1	10.5
15	7.1	10.6

With respect to the harvesting system, plans exist to use small scale transportable chippers in the future to chip the smallest branches in the field.

The eucalyptus trees will be harvested during the dry season (December to April) to facilitate air drying, down to a moisture content of about 20% during a period of one month. The logs then will be chipped and fueled into the plant. The plant is expected to run about 150 days fueled by bagasse and 180 days fueled by fuelwood. Estimated fuelwood costs are around
US$ 25.00/Ton(20%mc) (Coronel, 1997).

3.2. THE POWER SYSTEM

Figure 3 shows the scheme of the Victoria de Julio sugar mill power plant. The plant was designed to have 36 MW_e of total installed capacity for a crushing rate of 7000 tons/day. At this moment 12 MW_e (3 x 4 MW_E) is already installed. Although the others two 12 MW_E turbines, on which the power sales are mainly based, have been available at the sugar mill for more than 8 years, they were never installed. The main reasons were that due to economic recession, the milling capacity was still heavily underutilized, and there was no demand for extra power capacity in the country.

Recently, with the privatization of the mill and the opening of the electrical market for private investors, the original plans were revived again. The extension that is needed at this moment, thus mainly consists of the installation of the two 12 MW_E turbines and upgrading of the existing boiler system.

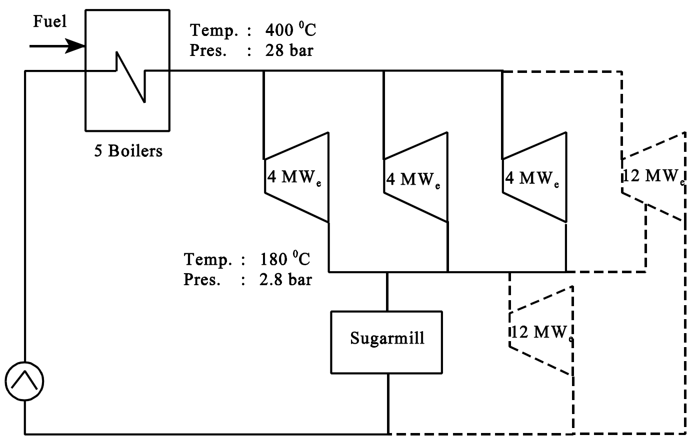

Figure 3. Scheme of the Victoria de Julio sugar mill; dotted lines indicate the extensions

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 harvesting 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 sugar mill. Because of the relatively low steam temperature, the net electrical efficiency will remain limited to about 20%(at LHV).

At the moment, operating at 75% crushing capacity, this mill is exchanging for few months each year 4 MW_E with the national grid. In the future a contract is expected to be negotiated about 0.06 $/kWh (Gallo,1997). By 1999 the plans are to further improve crushing capacity, to have the full 36 MW_E installed, and to be able to deliver 16 MW_E during the sugar cane crushing season, and 31 MW_E during the off-season (Table 2). The self-consumption of the sugar mill and the power plant is about 8 MW_E during the season and has a peak of about 4 MW_E during the off-season.

Table 2: Power production (MW_E) and distribution for AGROINSA today and the near future (Detrinidad,1996)

	BEFORE 1 9 9 9		**AFTER 1 9 9 9**	
M W $_e$	SEASON	OFF-SEASON	SEASON	OFF-SEASON
OPERATIONAL CAPACITY	12	0	24	36
SELF-CONSUMPTION	8	4	8	4
EXPORT	4	0	16	31

4. COSTS AND IMPACTS ON THE MACRO-ECONOMY

Recently, data have come available from the earlier mentioned study by van den Broek, comparing power generation from eucalyptus by the sugarmills with power generation from fueloil (Broek, 1997b). This study shows that power generation from eucalyptus can be delivered for about the same price as power from fueloil (0.066 against 0.065 $/kWh). Furthermore, considering the macro economic impact, with eucalyptus about 67% of the price of electricity stays within the national economy (thus adding to the Gross Domestic Product), while with fueloil this ranges between 14 and 29%. Also, employment generation is about 3 times larger with eucalyptus.

5. CONCLUSIONS

In Nicaragua the economic reforms are opening the way to a more participatory and competitive presence of the private enterprises in the energy sector. The sugar industry is facing new opportunities to diversify its production into power generation. Here a new concept is being implemented where the sugar mills besides generating extra power for sale during the cane crushing season, also are becoming a full power plant during the off-season by burning fuelwood from plantations.

This initiative is among the first in the world to use a dedicated energy crop to generate power during the non-harvesting season. The impacts of this concept could be high, since all over the tropical sugar cane producing countries, new power is much in need, and the possibility of avoiding fossil fuel imports and promoting the cultivation of trees is very welcome.

While the cost of power production with eucalyptus by sugarmills is about the same as the cost with fueloil, the socioeconomic and environmental impacts appear to be significantly better.
Power generation based on dedicated energy crops is not only a future option, but looks attractive at this moment for the Nicaraguan sugar mills.

6. ACKNOWLEDGMENTS

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