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Optimizing Sugar Milling Profits Using 2nd Generation Biomass Technology

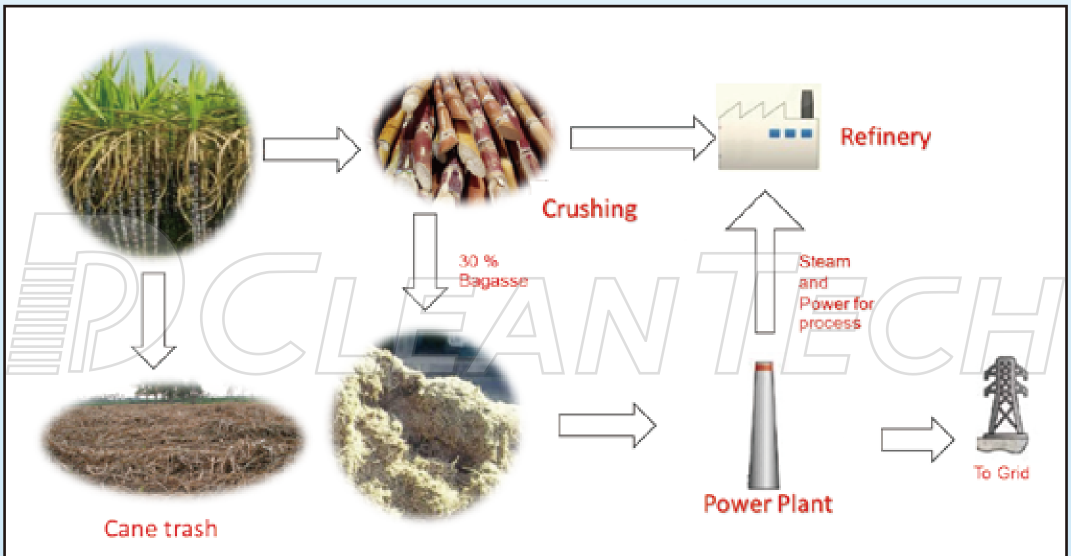
Introduction

Sugar crop processing is an energy intensive practice, requiring both steam and electricity. Cogeneration is a well-known process in the sugar industry and it is used in nearly every single sugarcane mill or beet factory. Practically every phase in sugar manufacturing (juice extraction, bagasse/pulp drying, juice purification, evaporation and crystallization) requires heat and the processing stage needs electricity. Cogeneration boilers take the waste product from the sugar milling process to create steam and electricity that is fed back in to the milling plant creating a closed loop energy cycle.

Relatively low-temperature technology boilers generate sufficient electricity to meet the processing need of a plant. However, high temperature technology boilers will provide sugar processing plants with cheaper heat, and will also produce electrical outputs in surplus to the internal processing needs of the plant. This excess output can then be exported to the national grid, thus potentially providing a cost-efficient means of cutting production costs, reducing pollution and generating additional revenues for the sector. However this will of course depend on the ratio between the price secured and production cost of electricity generated in the sugar industry.

The milling process

The crushing process at sugar mills generates a waste product called bagasse. Bagasse is an effective, high calorific value biomass fuel which is burned in the boiler furnace producing high temperature, high pressure steam, which is then supplied to the turbine. The turbine drives an electrical generator and the steam exiting the turbine exhaust flows to the heating equipment for sugar manufacturing.



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Economic drivers

Additional income revenues from electricity sales to the national grid may contribute substantially to the economic viability of the sugar sector. Calculating the potential energy gains from cogeneration in the sugarcane processing industry is not a straightforward exercise due to the fact that the energy value of bagasse is a function of cogeneration system parameters.

For illustration purposes, however, one can use a flat coefficient1 tonne of bagasse (50% moisture) = 0.213 tonne of crude oil*. Thus, if global production of bagasse is estimated at 424.186 mln tonnes (see table 2), then potentially the sugarcane processing sector might annually generate the same amount of electricity from bagasse as from burning 90.41mln tonnes (662.4 mln barrels) of crude oil with a market value of USD 66.2bln even at today's prices (USD100/barrel)**.

*Source: Ministry of Mining and Energy of Brazil in National Energy Balance, 2008

**Source: International Sugar Organization – Cogeneration, opportunities in the world sugar industries, 2009

Table 2 Global potential bagasse availability – 2007 (thousand tonnes, 50% moisture)*

South America	132,182	Asia	198,139
Argentina	7,165	China	40,913
Bolivia	1,223	India	94,834
Brazil	108,228	Indonesia	9,174
Colombia	7,423	Pakistan	14,165
Ecuador	1,614	Philippines	7,000
Peru	2,950	Thailand	23.298
Venezuela	2,282	Vietnam	4,078
Others	1,297	Others	4,677
Central America	**20,749**	**Africa**	**28,076**
Costa Rica	1,215	Egypt	3,810
Cuba	3,890	Ethiopia	1,108
Dominican Republic	1,592	Kenya	1,697
El Salvador	1,825	Mauritius	1,507
Guatemala	7,705	South Africa	7,454
Honduras	1,271	Sudan	2,424
Nicaragua	1,646	Swaziland	2,058
Others	1,605	Zimbabwe	1,139
		Others	6,879
North America	**28,166**	**Oceania**	**16,034**
Mexico	17,669	Australia	15,084
USA	10,497	Others	950
WORLD	**424,186**		

Source: Energy Data Associates, UK, March 2009

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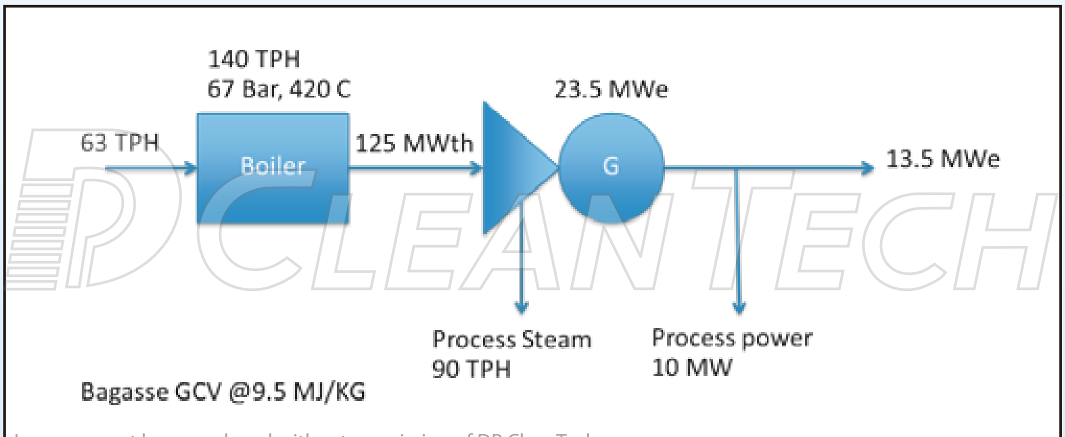
Using advanced high pressure systems to maximize potential

Worldwide, most sugarcane mills have achieved energy self-sufficiency for the manufacture of sugar. Many mills generate a small amount of surplus electricity during the peak of the crushing season. However, the use of traditional equipment such as low pressure boilers inhibits the potential electricity output. Using low pressure boilers does not enable sufficiently high or reliable levels of electricity production to change the energy balance, and permit exports to the electric power grid.

Typically, the processing of one tonne of cane yields about 250-280 kg of bagasse (with moisture level of 50%), which can generate 500-600 kg of steam, close to the 400-600 kg of steam consumed in the processing.

However the use of more efficient high pressure boilers together with condensing extraction steam turbines can substantially increase the level of exportable electricity without varying the quality of fuel.

As an example, a standard 6000 tpd mill will have the following energy balance:



Source: DP CleanTech, 2013

By installing a high pressure, high temperature solution, the mill will be able to upgrade its performance. A 12% reduction in bagasse consumption can still increase power generation by 13%.

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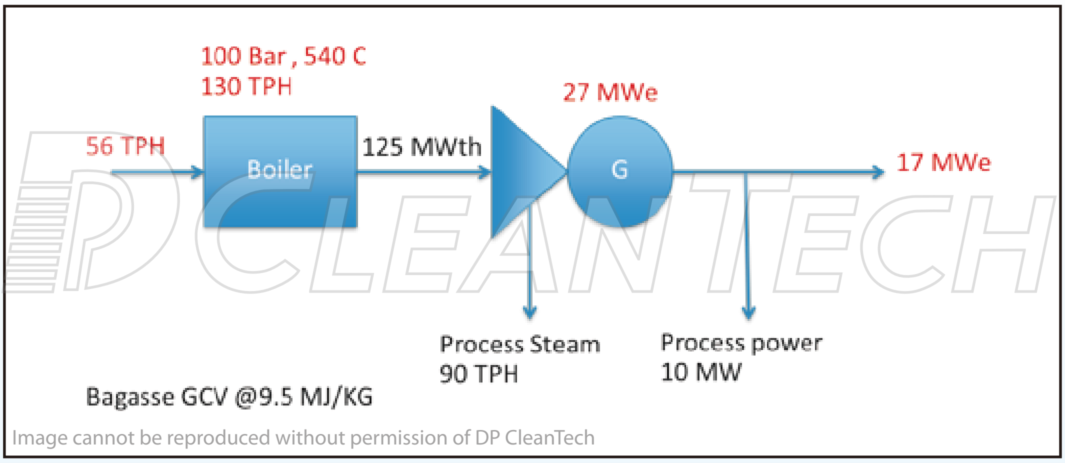
Energy diagram of 6000 TPD mill with a 2nd generation power solutions:



Source: DP CleanTech, 2013

Other important aspects to ensure success

In technical terms, the amount of energy that can be extracted from bagasse is largely dependent on two main criteria: the amount of processed cane and the technology used for energy production. The cost of boilers and their installation is relatively high but, with many projects in Brazil and Thailand, capital investment costs may be recovered by revenues from electricity exports to the national grid in a period not longer than 5 years.

The success of cogeneration by sugarcane mills is fully dependent on the existing legal framework and the prevailing electricity market rules. Firstly, the electricity generation and supply to the national grid has to be allowed for sugarcane mills. Secondly, prices paid to mills by the utility company have to be adequate. Power Purchasing Agreements have to be long-term. The legal framework has to ensure fair and easy access to the grid for sugar mills. Government incentives like feed-in-tariffs can also be very helpful in maximizing projects profits. Currently Thailand and Philippines offer the best regulatory framework for biomass power development in South East Asia.

The Challenge of fuel availability

A separate challenge being addressed is availability of bagasse fuel. Electricity distributors and consumers need uninterruptible base load power supply throughout the year. Taking into consideration the high seasonality of sugarcane harvesting and processing, such availability is difficult to achieve if the fuel is solely bagasse-based. This bottleneck is now being increasingly resolved by enabling boilers to co-fire with other varieties of fuel to ensure year round availability. The use of cane trash in power generation in the future, seems particularly promising, however the technology has not been available until recently.

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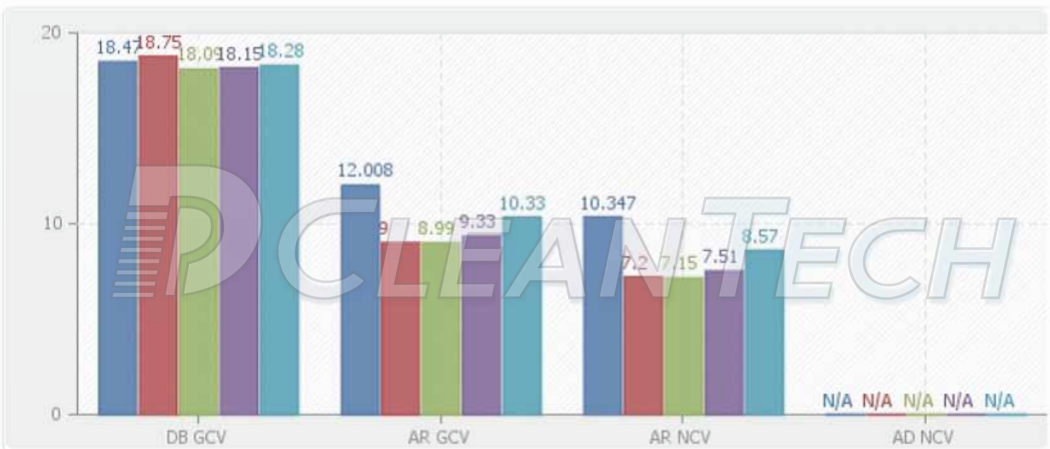
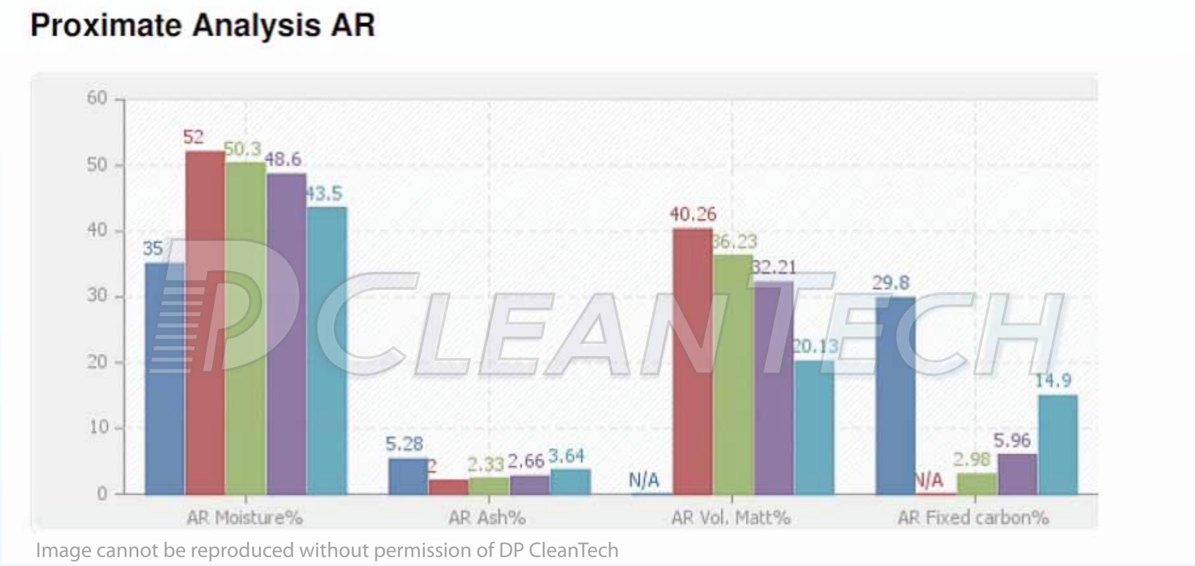
Using Cane Trash

Sugarcane trash or 'cane trash' is essentially the tops, dry and green leaves left in the field after harvesting. It is considered to have high potential as an alternative fuel for cogeneration in addition to bagasse. The amount of trash produced depends on the plant variety, age of the crop at harvest and soil and weather conditions. Typically it represents about 15% of the total above ground biomass at harvest which is equivalent to about 10-15t /ha of dry matter (Bell et al., 1999; Mitchell et al., 2000; Robertson and Thornburn, 2000). During the harvesting operation around 70-80% of the trash is left in the field with 20-30% taken to the mill together with the cane stalks as extraneous matter (Macedo et al., 2001). Cane trash has a similar calorific value to bagasse but has an advantage over bagasse in that it has lower moisture content, and hence dries more quickly, see below proximate analysis taken from DP CleanTech Biomasslab.

- Cane trash
- Sugar cane bagasse, Philippines
- 10% Cane trash
  90% Sugar cane bagasse, Philippines
- 20% Cane trash
  80% Sugar cane bagasse, Philippines
- 50% Cane trash
  50% Sugar cane bagasse, Philippines

Calorific values





Source: DP Cleantech Biomasslab

Technical and economic issues with cane trash

Economic challenges

The recovery of cane trash from the field and transportation to the mill are major issues. Either cane is separated from the trash by the harvester and the two are transported to the mill separately; or the whole crop is harvested with separation of the cane and the trash carried out at the mill. This remains an economic challenge in many countries, but some countries have made this viable. In Brazil, recovering the trash from the field (as baled trash) is estimated to cost US$20.54 /t, which corresponds to US$ 1.35 / GJat the lower heating value (Macedo et al., 2001).

Technical Challenges

Although cane trash does have a lower moisture content than bagasse, it has a more complicated chemical composition with high levels of Chlorine and a lower ash fusion temperature which results in higher propensity for fouling and corrosion. See the following graph from DP Biomasslab.

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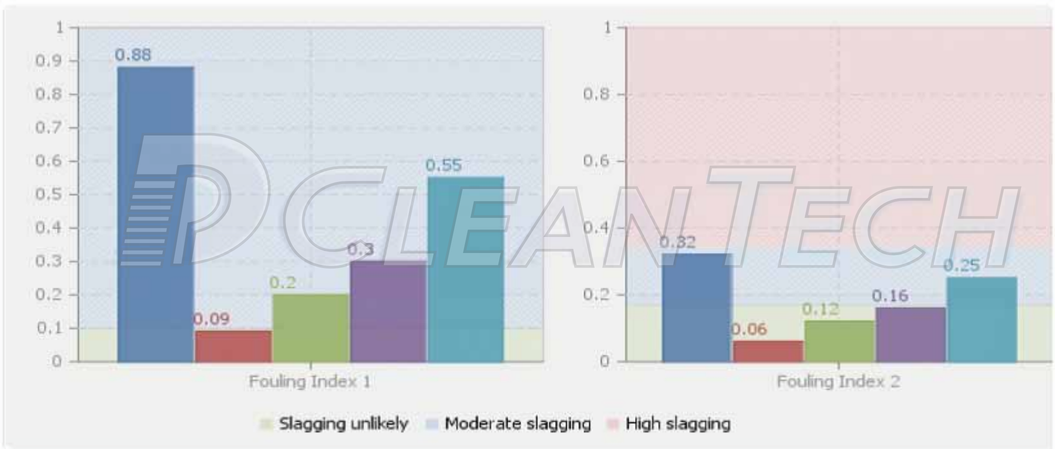
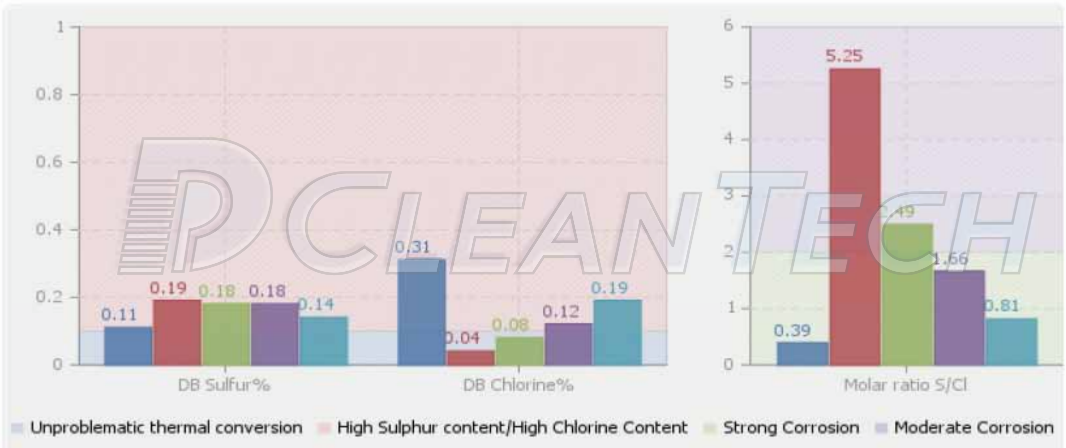
Fouling Analysis



Corrosion Analysis



Source: DP Cleantech Biomasslab

Corrosion and fouling can cause serious damage to the boiler walls and tubes containing high pressure steam. When using fuels that have a higher propensity for fouling and corrosion, it is very important to make appropriate alterations to the design to avoid reduced performance and downtime.

In fact cane trash presents more chemical similarities with wheat straw than it does with bagasse. There for DP Cleantech has been developing a specialized solution to deal with bagasse, cane trash fuel mixes.

The solution developed by DPCleantech allows the sugar mill to burn bagasse as well as a large amount of cane trash and other fuel like wood chips or rice husk. The boiler has been designed to operate with a large range of fuel and is equipped with some very specific design features:

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- The combustion system is extremely versatile and allows controlling of the combustion for each fuel scenario, the Grate Vibration will be controlled; FD and ID are bigger and equipped with VFD to be able to control the Flue gas velocity in synchronisation with boiler load changes due to varying fuels.

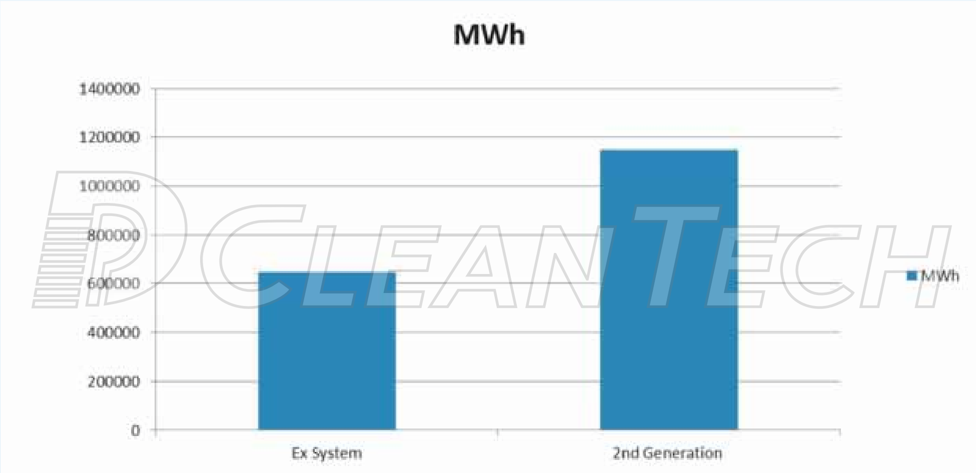
- The Boiler design, size, choice of material and heat exchange takes into consideration the variation of behavior from the fuel in fouling, corrosion and erosion and, of course, calorific value.

- The extensive boiler instrumentation allows a precise and fast control of the plant operation.

- Flue gas cleaning also needs to be able to handle different type and quantity of ashes depending on the range of fuel burnt and always keep the emission below the requirements for Particles Matter.

From Sugar Mill to IPP

A 6000 tpd mill has access to 300,000 tons of bagasse and 76,500 tons of Cane Trash. By using a multi-fuel high pressure high temperature boiler, the mill can double its power export capacity and generate electricity almost all year round.



Those additional revenues for the mill are considerable and are transforming the industry.

Today a sugar mill produces more than sugar. It can be an Independent Power Producer, that also produces sugar. It can increase the profitability of a sugar mill, as well as make positive contributions to balance the energy mix.

This article complements the presentation made by Jerome Le Borgne, Southeast Asia, Africa and Pacific Sales Director, DP Cleantech at PowerGen Asia 2013.