Comparative Environmental Analysis of Sugarcane Technologies

Fives Cail Advertorial

IN RECENT TIMES THE SUGARCANE INDUSTRY HAS UNDERGONE SOME IMPORTANT CHANGES WITH RESPECT TO ENERGY CONSERVATION, DIVERSIFICATION AND ENVIRONMENTAL FACTORS. THE FIRST CHANGE LEADS TO A BETTER APPRECIATION OF BAGASSE TO PRODUCE STEAM AND ELECTRICITY. THE SECOND CHANGE INVOLVES DIVERSIFYING THE USE OF SUGARCANE, WHICH IS BECOMING A FEEDSTOCK TO PRODUCE ELECTRICITY, ETHANOL AND CO_2. IN THIS CONTEXT, THIS ARTICLE AIMS AT QUANTIFYING THE ENERGY AND GREENHOUSE GAS (GHG) IMPACT OF THE MAIN TECHNOLOGIES USED IN THE SUGARCANE PROCESSING INDUSTRY.

Technologies evaluated are cane preparation (cane knives / gravity shredders versus In-Line Shredder), juice extraction (mills versus MillMax® and diffusers), evaporation (rising versus falling film) and crystallization (batch pans versus continuous pans). The factory considered produces raw sugar, cogenerates power and employs conventional technology (table 1). Reported electricity and steam consumption result from measurements carried out on site.

Assessing the Environmental Balance of Sugarcane Processing Technologies

Cane Preparation

Table 2 shows the main characteristics of preparation technologies. In-Line Shredder consumes 16% less energy than conventional technology, resulting in yearly surplus of 3300 MWh available. GHG emissions are also 16% lower for the In-Line Shredder.

TABLE 1 – MAIN DATA

ITEM		VALUE
Cane	Cane Processing Rate	10000 t/day
	Fibre	14%
	Crop Duration	210 days
Factory	Boiler	60 bar 470 °C Process steam: 2 bar
	Front-end	Set of cane knives, gravity fed shredder Preparation Index > 90% 5 conventional mills Electric motors Imbibition: 250% on fibre Bagasse moisture: 50% Pol extraction: 96.3%
	Sugar process	5-effect rising evaporation station Crystallization: 3 strike batch pans
Emission factor	Electricity (Brazil)	283 kg CO_2e / MWh CO_2e = Carbon Dioxide equivalent

TABLE 2 - CANE PREPARATION TECHNOLOGIES		
TECHNOLOGY	**CONVENTIONAL PREPARATION**	**IN-LINE SHREDDER**
Main components	1 main conveyor 1 leveller 2 sets of cane knives 1 auxiliary conveyor 1 gravity fed shredder Electric drives	1 main conveyor 1 leveller 1 In-Line Shredder Electric drives
Absorbed power	4064 kW	3403 kW
Annual electricity consumption	20482 MWh	17151 MWh
GHG annual emissions (electricity consumption)	5800 t CO_2e/year	4900 t CO_2e/year

Juice Extraction

Table 3 notes the main characteristics of conventional mills, MillMax® and diffuser. The total balance, taking into account both electricity and steam consumptions, gives the advantage to MillMax®, followed by diffuser and by conventional mill with a maximum yearly surplus of 7900 MWh. GHG emissions are the lowest with MillMax®.

TABLE 3 – JUICE EXTRACTION TECHNOLOGIES			
TECHNOLOGY	**CONVENTIONAL MILLING TANDEM**	**MILLMAX® TANDEM**	**DIFFUSER**
Main components	5 mills Electric drives	5 MillMax® Electric drives	1 diffuser 2 dewatering mills Electric drives
Absorbed power	4215 kW	2646 kW	2196 kW
Electricity consumption	21244 MWh / year	13336 MWh / year	11068 MWh / year
Export of electricity due to extra steam consumption	0 (reference)	0	-4202 MWh / year
GHG emissions	6000 t CO_2e / year	3800 t CO_2e / year	4300 t CO_2e / year

Juice Evaporation

Table 4 presents characteristics of rising evaporators (Roberts or Kestner type) and falling film evaporators evaluated with quadruple or quintuple effect stations. Falling film evaporators allows exporting approximately 2000 MWh more than rising evaporators. A quintuple effect station makes it possible to export some 16000 MWh more than a quadruple effect station. Falling film evaporators avoid 500 tonnes emissions of CO_2e per annum compared with rising evaporators. A quintuple effect station avoids 4250 tonnes emissions of CO_2e per annum compared to a quadruple effect one.

TABLE 4 - JUICE EVAPORATION TECHNOLOGIES

TECHNOLOGY	4 EFFECTS RISING EVAPORATORS	5 EFFECT RISING EVAPORATORS	4 EFFECT FALLING FILM EVAPORATORS	5 EFFECT FALLING FILM EVAPORATORS
Main components	4 evaporators	5 evaporators	4 evaporators	5 evaporators
Crystallization	3 strikes batch pans Optimized bleedings	3 strikes batch pans Optimized bleedings	3 strikes batch pans Optimized bleedings	3 strikes batch pans Optimized bleedings
Steam consumption	414 kg/tc	360 kg/tc	403 kg/tc	350 kg/tc
Exported electricity	0 (reference)	15290 MWh/year	2240 MWh/year	17110 MWh/year
GHG avoided emissions	0	4300 t CO_2e/year	600 t CO_2e/year	4800 t CO_2e/year

Crystallization

Table 5 shows the main characteristics of batch pan and continuous vacuum pans (CVPs). The total energy consumption is decreased by 10% with continuous pans compared with batch pans. This makes it possible to export 10400 MWh more per year. Continuous crystallization avoids emitting 3000 tonnes of CO_2e per annum compared to batch crystallization.

TABLE 5 - VACUUM PAN CRYSTALLIZATION TECHNOLOGIES

TECHNOLOGY	CVPS	BATCH PANS
Main components	3 strikes CVPs	3 strikes batch pans
Steam consumption	330 kg/t cane	360 kg/t cane
Exported electricity	10400 MWh / year	0 (reference)
GHG avoided emissions	-3000 t CO_2e /year	0

Conclusions

The evaluations of the energy performances and the GHG emissions of a sugarcane factory emphasize that technologies supplied by Fives Cail are energy-efficient and leads to low GHG emissions:

- In-Line Shredder (- 16% consumption compared to the conventional preparation) and MillMax® (- 37% consumption compared to the conventional mills) for the front-end,

- 5 effect falling film evaporators (- 3% consumption compared to 5 effect rising evaporators and - 13% consumption compared to 4 effects rising evaporators) and continuous vacuum pans (- 10% consumption compared to batch pans) for the sugar process,

- In total this adds up to 23 GWh per year or 11 kWh / tonne cane being additionally available for export.

When a manufacturer cogenerates his electricity and his steam, the use of high pressure boilers, then the electrification of the front-end and finally the use of technologies saving electricity and steam will enable him to export more electricity, which will be a significant source of revenue.

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