Environmental Development 15 (2015) 35–51

Contents lists available at ScienceDirect

Environmental Development

journal homepage: www.elsevier.com/locate/envdev

Sugarcane processing for ethanol and sugar in Brazil

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ARTICLE INFO

Article history:
Received 15 November 2014
Received in revised form
15 November 2014
Accepted 19 March 2015

Keywords:
Sugarcane
Ethanol
Sugar
Electricity

ABSTRACT

Sugarcane has been used as feedstock for production of ethanol on a large scale basis in Brazil for over three decades, where most of the sugarcane mills produce sugar, ethanol and electricity. In this study the technologies usually employed in sugarcane mills in Brazil are briefly described, along with opportunities for process improvements and suggestions for the future of the sugarcane industry. These technologies and improvements can be improved, adapted and replicated to other countries using new technologies and alternative feedstock throughout the world.

1. Introduction

Brazil is a traditional sugar producer since the beginning of the XVII century, and ethanol started to become an important product for transport sector in the early XX Century, using molasses from sugar production as feedstock. The presently prevailing production model where ethanol and sugar are

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http://dx.doi.org/10.1016/j.envdev.2015.03.004
2211-4645/

produced in an integrated process became important after the launch of the Brazilian Alcohol Program (Proalcool) in 1975, when the urgent necessity of expanding ethanol production was met mainly by annexing distilleries to existing sugar mills (Soccol et al., 2010). After the second oil shock in 1979, the government decided to increase even further ethanol production, thus autonomous distilleries were deployed. However, with the sharp fall of oil prices in 1986 and the consequent decrease of government interest on the ethanol program, the production stagnated. In 1990 the government began to deregulate the sector and sugar exports were liberated, so Brazil became a very competitive sugar producer: exports increased from around one million tonnes in 1991 to 19 million tonnes in 2007 (MAPA, 2014). As a consequence, sugar factories were installed annexed to existing autonomous distilleries, consolidating once again the prevailing model of producing sugar and ethanol in an integrated way. Nevertheless, in the recent new expansion phase that started in 2004, several autonomous distilleries were built to attend the expected future demand of ethanol, both domestic (mostly driven by the flex fuels engines) and international (mostly driven by the need of renewable fuels to attend mandates of target reduction of greenhouse gases emissions in several countries).

The sector is currently in a transition from processing burned whole cane to unburned (green) chopped cane due to the gradual phase out of sugarcane burning (Alonso Pippo et al., 2011). Even though the government established a longer time frame for phase out of sugarcane burning, due to environmental and economic reasons, the sector itself decided to reduce that time frame and totally extinguish sugarcane burning (in mechanized areas, where soil declivity is lower than 12%) by 2014. Thus, manual harvest has been increasingly replaced by mechanized unburned harvest (Galdos et al., 2013). Therefore, the sector has been facing changes in the sugarcane quality (mainly increased external matter content), with consequent impacts on cane processing and on soil characteristics.

In this work, the prevailing sugarcane processing technologies and the corresponding improved technologies, using the most common processing model (combined ethanol and sugar production) as reference are briefly described. After that, some critical opportunities for process improvements and some suggestions for the sustainable future of sugarcane industry in Brazil are proposed.

2. Sugarcane processing

In a typical sugarcane mill, the stages illustrated in Fig. 1 are present.

The typical mill has an upfront section that is common to the ethanol distillery and sugar factory composed by the following processes: cane reception, cane preparation and juice extraction. The extracted juice is sent to the juice treatment system, in which impurities are removed from the juice in order to provide an adequate material for the subsequent steps; although most of the operations of juice treatment are common for both sugar and ethanol production, each process has its own specificities. During processing in the sugar factory, a concentrated residual solution obtained after sugar crystallization (molasses) is produced. Sugarcane juice from the ethanol juice treatment is blended with molasses, fermented using yeast (which is recovered and reused in the fermentation process), and the fermentation product containing ethanol is sent for distillation and dehydration. In the sugar house the juice is concentrated, crystallized, centrifuged and dried.

All the energy (steam and electricity) needed in this process is produced by the mill using sugarcane bagasse as fuel. In many mills surplus power is generated for sale to the grid. Some mills have been recovering a fraction of the sugarcane straw (sugarcane tops and leaves) and using it as fuel as well, however this is not yet a common practice in Brazilian facilities due to high recovery costs and questions about short and long term soil implications (Cardoso et al., 2013). However, sugarcane burning phase out provides an opportunity for straw use.

In Sections 2.1–2.3 the prevailing process technologies are briefly described.

2.1. Shared operations

2.1.1. Cane reception

Upon arrival at the factory, mechanically harvested sugarcane is discharged upon tables and sent to the cleaning system or directly to the feeding tables that lead to the cane preparation section. In the