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USE OF THE WATER IN THE PRODUCTION OF ETHANOL FROM SUGARCANE

Gilberto de Martino Jannuzzi

INTRODUCTION

The production of ethanol from sugarcane in Brazil has increased significantly during the last few years and it is expected to continue to expand over the next decades. This is partly the result of the high volatility of petrol´s prices and, also due to the increasing international market for a renewable liquid fuel for the automotive sector. The use of ethanol from sugarcane can also meet the requirements from the Kyoto Protocol by industrialized countries.

Besides being a potential source of renewable energy, contributing to the substitution of fossil fuels, the sugarcane culture is also known for the significant socio-economic and environmental impacts it brings along in the areas this culture gests established. The projected expansion of the Brazilian ethanol production over the next decades would certainly cause significant and diverse impacts in the producing regions. Many of the cumulative effects over time, including more population, introduction of new infrastructure and services, commercial and industrial activities will altogether increase the pressure on the local resources, including fresh water resources. These impacts must be considered by any sustainability analysis.

For the most part, the production of sugarcane in Brazil is rainfed and there is no need for artificial irrigation. However, the use of irrigation is becoming more common as new areas are being incorporated specially in South-Center region of Brazil. Besides the agricultural production, the industrial processing of sugarcane into ethanol is also very demanding on water resources.

TABLE 1 Fresh water use in Brazil.

Sector	Water consumption (%)
Agriculture and cattle raising	61
Urban uses	21
Industry	18

Source: CARMO (2008).

The main point of this chapter is to discuss the current situation of water utilization in ethanol production, the main challenges at the moment and future perspectives to guarantee less impact on the existing water resources.

The chapter is based on presentations delivered at the workshop "The use of water for production of ethanol from sugarcane"[1].

SUSTAINABILITY AND THE WATER USE

In general agriculture is the main consumer of fresh water resources in Brazil, as it can be noticed from Table 1. The industrial use of water is increasing in the country and consequently there is more concern with developing industrial systems with reduced water usage.

The most appropriate methodology to analyze and quantify water usage follows the same principles of the life cycle cost analysis (LCA). This

[1] Available at: <http://www.apta.sp.gov.br/cana/>.

methodology quantifies the materials (including water) and energy floods of the whole cycle of production until the final destiny of the product. In case of ethanol this includes the agricultural phase (plantation, harvest, transportation etc.), the industrial phase (washing, fermentation, distillation etc.) and the final use in vehicles. The agricultural part and, especially, the industrial phase, both are most relevant ones in case of the use of water.

Sustainability

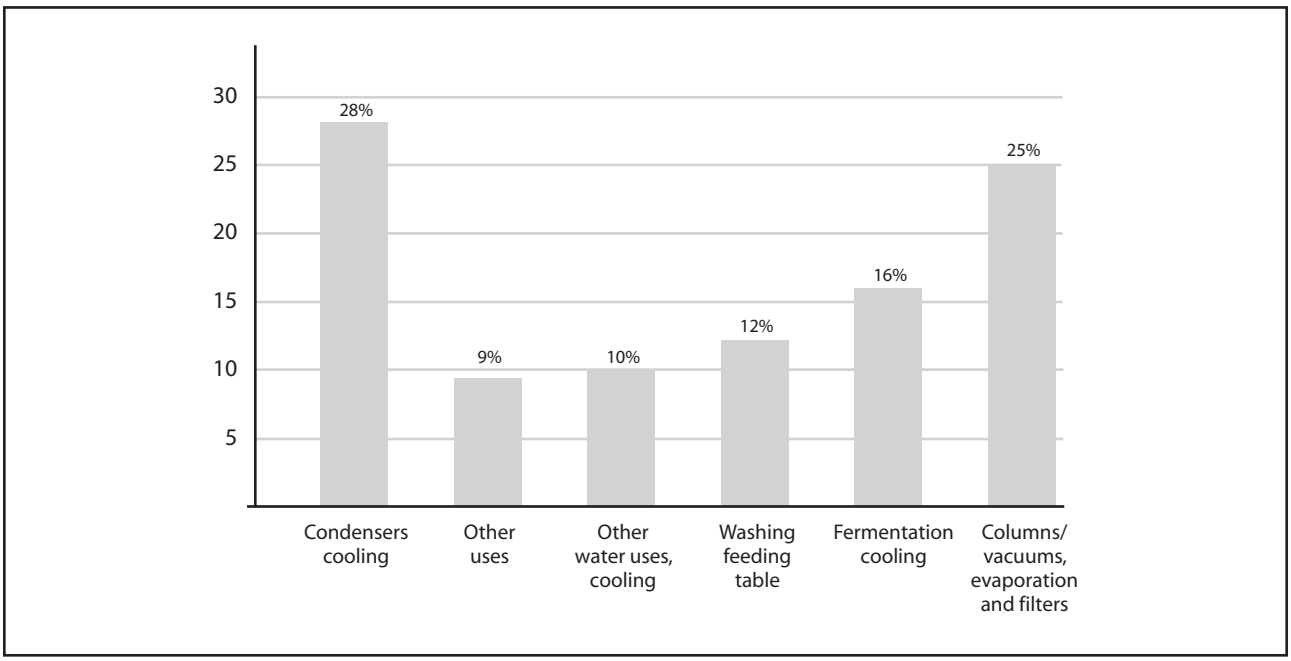
Sustainability is a normative concept; it contains values, perceptions and preferences that precede a technical and scientific analysis. The definition that is most used is the one that is mentioned in the Brundtland report (World Commission for Environment and Development WCED, 1987). Under this concept a society is considered sustainable when it is capable to fulfill the present generation' requirements and also preserve or maintain possibilities so that future generations can also meet their own requirements.

Leite (2008) observes the need to define indicators as to be better analyze questions related to the sustainability of the water use. He shows two concepts to characterize sustainability: water needs and water availability for the production system.

With reference to the amount of water needed for the production of ethanol, during the agricultural period the required amount is minimum, considering the current areas where sugarcane is grown in Brazil. Most of the sugarcane production is concentrated the State of São Paulo where it is cultivated without irrigation. Artificial irrigation is becoming more common in expansion areas that have insufficient or poor distribution of rainfall over the growing period. In São Paulo state where is usual to practice the midyear plantation, or full year plantation irrigation is not used. The winter plantation, which happens in a dry climate, needs a salvage irrigation for security, with the recommendation of having two irrigation with about 30 to 40mm of water, but is not very useful in south-east.

Irrigation is more necessary in the northeast region of Brazil, where the salvage irrigation is practiced after the cane plantation, and when needed a supplementary irrigation is also applied to complement the water deficit.

Although the need for water for industrial processes is more significant there are variations



Source: LEITE (2008).

FIGURE 1 Industrial water usage – distillery producing ethanol (50%) and sugar (50%).

between distilleries depending on the type of system that is being applied. Distilleries using an open cycle (do not reuse the water) have a need of 21m^3 of water/ton of cane. Illustration 1 presents the water distribution usage of a typical distillery operating with open cycle and allocating 50% of cane input for the sugar production and other 50% for ethanol.

The three final uses respond for almost 80% of the water industrial consumption: cooling condensers (28%), production of vacuum on the barometric columns (25%) and cooling of fermentation chambers (16%).

Leite (2008) presents recent developments that has been taken place in different distilleries:

Water cooling of condensers and fermentation chambers – Water in this circuit is been used through a cascade effect – so that the water from the fermentation chambers can be used afterwards on the condensers; this reduces in 16% the amount if water needed. The circuit has now been closed in some distilleries. Systems of evaporative cooling-towers are being employed, and water only is required to replace the amount lost by evaporation or dragging – about 2 to 3% of the water circulation.

There are studies in course regarding the use of colder water in this circuit with further benefits reducing the volume of water in circulation (these studies must be intensified).

The process of sugarcane washing – The cane washing is used as a closed water circuit system with decantation boxes or circular decanters. Dry cleaning systems are also being employed and water is only used when a great deal of inorganic matter is detected on the cane. The washing system using mats continues to be used but with smaller volumes of water employed (the circuit was reduced from 10m^3/ton sugarcane, to 1 to 2 m^3/ton of sugarcane.

Water from the barometric columns – This circuit have been modified, substituting the multi-jets by the barometric columns, in order to produce vacuum during the phase of juice concentration, bringing about a reduction of 30% of the water needed in this operation. Closed water circuits are now a common practice, being applied in evaporative cooling systems by aspersion (spray) or cooling towers. There has been a lot of research and new technologies have reduced significantly the amount of water used.

Cooling water – This is the water used in circuits to cool parts of the milling machinery and turbo-generators. Most of these circuits are now closed, especially in distilleries that are using co-generation systems.

Other uses of water in the industrial processes include: equipment maintenance and cleaning, water for preparation of products, water for milling or diffuser etc.

There has been progress in reducing water use for the industrial processes, particularly in São Paulo. In 2005 the average value of water intake for a industrial plant was of about 1.83 m^3/t. sugarcane. Leite (2008) showed that in spite of an increase of 125% of ton of sugarcane processed in the State of São Paulo, there was a reduction of 26% of water use during the harvest of the period 1990/91 and 2007/08.

The State of São Paulo has initiated signatures of voluntary protocols with the alcohol industry as the Green Ethanol Protocol and also observing the technical indicators of Water Resources Conservation Plan.

THE RIVER BASINS SUPPORT CAPACITY, THE BASINS ASSOCIATION AND THE LICENSING OF NEW DISTILLERIES IN THE STATE OF SÃO PAULO

Special permits are required in the State of São Paulo for retrofits, expansion and/or alterations of distilleries facilities. Environmental licenses are required in these cases and are issue by the State Environmental Secretary.

An environmental zoning map has been in place for the State of São Paulo as well. This procedure has mapped regions where sugarcane is allowed to be cultivated. It also indicates the permitted water intake for industrial processes, that vary from 0.7 m^3/ton to 1 m^3/ton of sugarcane.

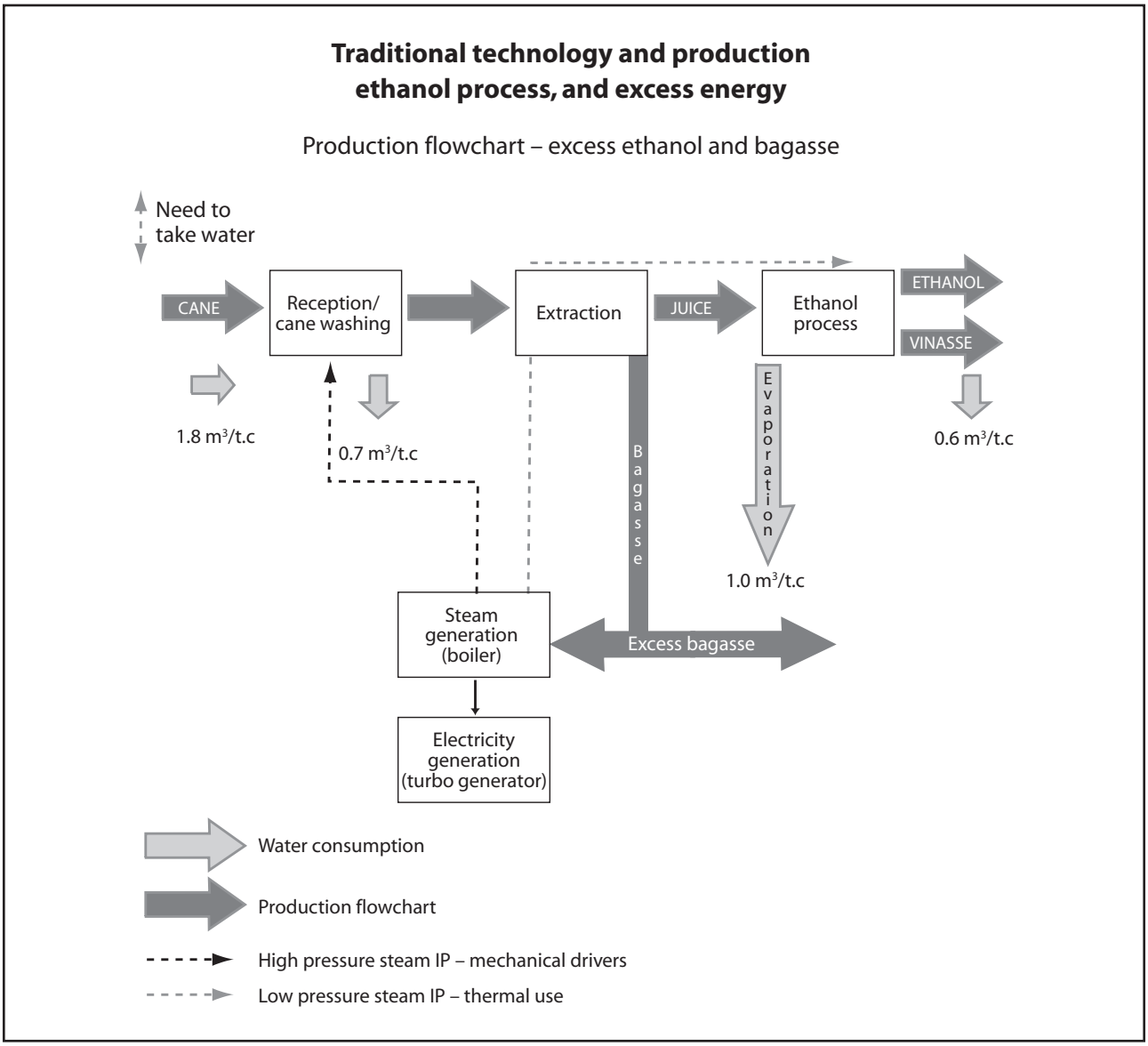
There are also four environmental control programs in the state with direct impacts on the activi-

ties of the ethanol and sugar sector: 1) The control of the quality of superficial and underground water (contamination by pesticides); 2) The controlling of the fauna (maintenance of preservation areas and buffer zones); 3) Atmospheric emissions and 4) agricultural soil preservation and quality.

According to the environmental zoning for the ethanol and sugar sector, the State of São Paulo has 3.9 million ha of suitable areas for sugarcane plantation and related industrial activities, 8.9 million ha of areas with some environmental limitations, 5.5 million ha of areas adjusted with environmental restrictions and 6.7 million ha of inadequate areas.

NEW MITIGATION TECHNOLOGIES FOR THE WATER USE IN THE PRODUCTION OF ETHANOL: INDUSTRIAL PHASE

Carmo (2008) presents new technological developments undertaken by the Dedini, with significant reduction in the water losses during evaporation, as well as using concentration processes of quantity of vinasse, dry washing and



Source: CARMO (2008) apud OLIVÉRIO (2008).

FIGURE 2 Ethanol production: water flow.

vapor uses. These reductions imply that the water that enters with the sugarcane juice (~700 liters for TC) is sufficient for the distillery operations, that is, the plant is self-sufficient in water, and there is no need to bring in outside water.

Figure 2 illustrates the flow of water use in the industrial conventional process of production of ethanol. The points most important are: the stage of washing the sugarcane; the stages of evaporation/condensation in the processes of sugar production and ethanol; the distillation (residual waters, water heater, washing of floor and tanks and discarding); the washers of the gases; the cooling of machinery and water use in boilers.

Some solutions to reduce the industrial water use:

- Replace the washing system of sugarcane by the dry washing system.
- Optimize the evaporation stage, tapping the steam and take advantage of condensation to produce water.
- With regards to the distillation and dehydration processes, new technologies with the use of membranes reduces the necessity of water.
- The concentration of vinasse integrated to the distillation process will be able to contribute significantly for the reduction of water needs.

Water consumption can be significantly reduced with the existing conventional technologies. The net water intake in the industrial process (it does not consider the water that enters with the sugarcane) can fall of 1.83 m^3/ton of sugarcane for 1 m^3/ton of sugarcane using available technologies, and can be further reduced to 0.5 m^3/ton of sugarcane as it was noted during the workshop discussions.

The advances in the rationalization of the use of the water in recent years have been relatively easy and they have not demanded large investments. As from now on, the efforts and resources will be bigger for a lesser reduction.

There are already better water-conserving technologies in the market, and research being done leading to water self-sufficient distilleries. However, the costs are still prohibitive.

NEW MITIGATION TECHNOLOGIES FOR THE WATER USE IN THE PRODUCTION OF ETHANOL: THE INCORPORATION OF THE STRAW FOR REDUCTION OF THE WATER STRESS

There is the option of using cane straw for covering the ground as a practice to conserve water and soil. The coverage by straws helps the retention of the humidity and reduction of the losses of organic matter and soil erosion. It also promotes gradual incorporation of organic substance into the ground. The amount of available straw in sugarcane allows enough vegetable matter to cover the ground to prevent significant losses of water and soil.

Nevertheless, the pursuit of sustainability implies in significant change of the technologies and processes currently used. This change means the adoption of direct plantation, harvest of the raw sugarcane (without the traditional process of burning the plantation prior to harvesting), use of structures of controlled traffic, the use of the straw.

The direct plantation presents as a very promising way to obtain conservation of the water and the ground. Water losses when using the conventional plantation system are about 140 mm/year, while the direct plantation is a little more than 40 mm/year. Soil losses in the conventional plantation and the direct plantation one are, respectively, about 23 ton/ha/year and little more than 5 ton/ha/year.

The traffic generated using current mechanization compacts the soil and hinders the use of direct plantation methods. Currently, 60% of surface of the planted areas are used for traffic of agricultural machinery. Using Structure of Controlled Traffic (ETC), the traffic area is reduced to 5-10% of the planted area.

The harvest of the raw sugarcane is one of the first conditions for the practical one of the direct plantation. However, according to Braunbeck (2008) there is the need to break with the current trend of technological standards in order to meet the goals of environmental protocols for areas

with declivities above 12 degrees. This is because of lack of interest of equipment manufacturers of agricultural machinery.

FINAL CONSIDERATIONS

1. About 20 years ago the average water consumption in the State of São Paulo was 5,6 thousand liters for each ton of processed sugarcane, today this relation is of 1.8 thousand liters for each ton, that is a 32% reduction, but we still can and we must do more. New ethanol production technologies, (second generation) might demand more water resources for the processes.
2. Significant progress are already being obtained as we reported during the workshop, such as the water recovery of vinasse, use of membranes for dehydration of ethanol, use of high-pressure boilers and other technological innovations.
3. Significant changes in technologies and processes are necessary for the conservation of the ground and the water, as the pressures will still be higher in the future.
4. Significant reductions in water consumption for industrial processes were achieved as results of negotiations with the State of São Paulo officials and the industry. The environmental zoning was an effective tool to organize the ethanol producing observing local resource limitations.
5. New technologies for water use in industrial processes have been introduced, such as dry systems, membranes for the distillation processes and dehydration. These innovations are becoming more common amongst the producing units. Technologies that they can also make use of the water contained in the sugar for industrial purposes is also being developed, and there are expectations that net excess of water can be achieved. In this way industrial units could potentially export water.
6. The reduction observed in the water intake for the industrial processes in São Paulo can be attributed to diverse factors that have occurred simultaneously: learning curve of operation of sugar mills and distilleries, together with the increase in production scale; scarcity of water reserves in several regions of the State; beginning of collection of fees for the use of the water; increased efforts related to environmental monitoring and more stringent regulation regarding the environmental licensing of new industrial units.
8. The environmental zoning performed in the State classifies regions where the plantation of the sugarcane is allowed, with parameters indicating the permited levels of water intake for the industrial processes that vary of 0.7 m^3/t of sugarcane to 1 m^3/t. The State of São Paulo has 3.9 million ha classified as suitable areas for the sugarcane activities, 8.9 million ha suitable areas with environmental limitations, 5.5 million ha of areas suitable areas with environmental restrictions and 6.7 million ha of inadequate areas.
9. The direct plantation presents as a very promising way to achieve water and soil conservation. Water losses using the conventional plantation methods are of about 140 mm/year, while by the direct plantation is a little more than 40 mm/year. The losses of soil matter in the conventional plantation are about, 23 ton/ha/year whilst by using the direct plantation method it comes down to a little more than 5 ton/ha/year.
10. It became clear also that a more rigorous methodology and data to quantify the water flows in the system of ethanol´s production (including agricultural and industrial the part) are required.

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