TECHNO-ECONOMICAL EVALUATION OF AN INTERACTIVE DISTILLERY-SUGAR MILL TO GUIDE DECISION-MAKING FOR THE BEST INCOME BALANCE

By

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Abstract

THE WORLD ethanol production has grown rapidly from the beginning of this decade, driven by its greater use as a fuel. For example, in 2001, 42% of the world ethanol production was directed to beverage, cosmetics and the chemical industry whereas, in 2008, this figure went down to only 20%, with 80% being used as fuel (bioethanol). In fact, the bioethanol production grew from 18 000 million litres in 2001 to an estimate of 66 000 million litres in 2008. This means that ethanol is today the main alternative liquid fuel and ethanol obtained from sugarcane is the only source that does not compromise food sources, and it induces a significant reduction in the green-house effect. The technological option of the combined production of ethanol from sugarcane juices and very high pol (VHP) sugars, with an additional contribution of surplus bagasse for electric co-generation, has great appeal. This paper presents a techno-economical evaluation, with an interactive model that can guide the decision making process in the sugar mill/distillery complex, to get the best income balance according to the sugar and ethanol prices prevailing in the world markets. A Cuban case study is presented.

Introduction

The changes in cane sugar production and electric co-generation, in addition to producing ethanol, establish the criteria for a new operational scheme that is being introduced in many countries (MECAS, 2008, 2009).

With the purpose of increasing the efficiency of ethanol production, to get higher competitiveness and better sugar quality, and diminishing dependence on crude oil, the economical impact of a new operational scheme is analysed for Cuban conditions.

In the case of the alcohol distillery, the molasses fermentation stage was found to be one of the most inefficient parts of the process, and some studies were carried out before the implementation of the designed scheme to improve the production technology.

The studies that were carried out indicated the need to employ an adequate yeast strain and supplementation with inorganic salts, all to get a lower blackstrap molasses consumption and a higher exhaustion of the fermentation substrate.

In the conventional scheme, not using the juices from the filters in the sugar production, around 90% of the cane juices are devoted to sugar production and only 10% are directed to ethanol synthesis.

When the system of ‘Two Massecuites’ is used in the sugar production and separating the juices from the filters for alcohol production, 82% of the extracted juices from the cane are used to produce sugar and 18% for ethanol, increasing the surplus bagasse from 36% to 42%.

With this new scheme, the amount of sugar obtained is reduced, because the juices from the filters are not used for that task; and because the 'Two Massecuites' alternative limits the sugar recovery up to the B molasses. Both elements had contributed to the increase in the quality of the raw sugar produced.

With the conventional way, a standard or medium quality raw sugar is obtained, with no more than 96 Pol; with the new scheme, it's possible to obtain a raw sugar with no less than 97 Pol, having wide market opportunities, higher prices, and increasing the net income.

Materials and methods

In this study, the increase in the net income obtained when the new scheme is applied is evaluated, having as a reference a Cuban Standard Mill, with a milling capacity of 2520 t of cane per day, with a constant alcohol production per day.

An incremental income is obtained by improvements in the efficiency of the distillery, as well as the increase in the quality of the sugar produced and the higher electric availability.

In the calculations of the income under both schemes, the prices prevailing in the Cuban national market are used (MARC, 2008).

The term 'extraction' is used to mean the technological step of using the extraction of the juices from the vacuum filters as substrate for the bioconversion to ethanol.

Results and discussions

The results obtained with the New Scheme are shown in Table 1.

Table 1—Blackstrap molasses input indexes for alcohol production.

Without extraction	With extraction
400 kg/hL	350 kg./hL

Source: ICIDCA internal data.

It must be taken into account that the raw material used in the substrate for the ethanol production—with the new scheme—is B molasses, a product of higher purity than the C molasses that obviously contributes to the increase in the efficiency of the ethanol production, reducing the unit input.

The production values obtained with both schemes are shown in Table 2 and Table 3. The bases for the calculations are represented in Table 4.

Table 2—Balance of production with the conventional scheme (three massecuites).

Daily production balance	Units	Values
Milled cane	Tonnes	2520
Sugar	Tonnes	314
Blackstrap molasses	Tonnes	86.80
Total ethanol production	hL	500
With own molasses	hL	217
With molasses from other sources	hL	283
Total Produced bagasse	Tonnes	195.30
Surplus bagasse	Tonnes	70.70
% of surplus bagasse	%	36.20

Note: Alcohol Production only with C Molasses. Distillery Operation for 270 days per year: 100 in sugar season + 170 days off-season.
Source: ICIDCA Internal report

Table 3—Production balance with the new scheme.

Daily production balance	Units	Values
Milled cane	Tonnes	2520
Sugar	Tonnes	237
Blackstrap molasses	Tonnes	86.80
Total alcohol to be produced	hL	500
Alcohol during season from filter juices	hL	378
Alcohol during season from own molasses	hL	122
Alcohol during off-season with own molasses	hL	74.12
Alcohol at off-season from other source molasses	hL	425.88
Total bagasse	Tonnes	195.30
Surplus bagasse	Tonnes	82.24
% of surplus bagasse	%	42.11
Equivalent conventional fuel	Tonnes of Bunker C	16.45

Note: Two Massecuites. Alcohol production with B molasses + filters juices.
Distillery operation for 270 days: In the sugar season 100 + 170 off-season.
Source: ICIDCA Internal Report.

Table 4—Calculation bases for the production balance. (obtained from every tonne of milled cane)

	Traditional	New
Sugar (t)	0.12	0.09
Alcohol (hL)	0.09	0.20
Blackstrap molasses (t)	0.03	0.03
Bagasse (t)	0.08	0.08
Filters juices	0.18	0.18
For 100 L of alcohol are needed	400 kg of blackstrap molasses	One t of bunker C oil is equivalent to 5 t of whole bagasse

Source: ICIDCA Internal Reports

The surplus bagasse is increased by 1154 tonnes per day, which represents an increase of 6%, and gives opportunities for higher generation and sales of electricity, if this bagasse is used as fuel.

The electric balance is the figure obtained when the electricity consumption of the sugar-alcohol complex is deducted from the total electricity generated by the installation.

The electric balance of the sugar- alcohol complex during the season has two options: when the bagasse in burned as fuel or when not.

In the second case, the electric deficit drives an increase of the production costs as it is forced to buy electricity from the national grid; if burned, the complex is self sufficient during the milling season, even having the possibility of selling electricity to the grid within the range of 2.51 to 2.98 MWh per day, for three or two massecuites respectively.

The alcohol remains constant in volume because there is no increase in the installed capacity. However, the need to transport molasses from other mills is dramatically reduced, because the ethanol plant can operate with its own molasses for a longer time, reducing the transportation costs of B molasses and giving a higher autonomy of production to the enterprise.

In Table 5, an increase in the total income of US$3m in the sugar-ethanol complex by the new scheme can be seen, when the bagasse is used as fuel to generate electricity.

Table 5—Total Income (USD) under both production schemes.

Product	No extraction	With extraction	Increased income
Sugar	1 330 104	2 604 156	1 274 052
Total alcohol	2 493 200	3 291 650	798 450
Electricity	417 463	637 511	220 048
Total	6 733 967	9 824 967	3 091 00.20

Source: Own figures from ICIDCA's internal reports.

Conclusions

The implementation of the proposed new scheme is in context with requirements and tendencies that are coming into force in world sugar industries. It allows an increase in the sugar quality, improving its commercialisation.

Additionally, a badly needed production flexibility is ensured in the sugar-ethanol combined manufacture, because the distillery can use juices and/or molasses and the whole range of their combinations, generating, at the same time, electricity, depending on the use of surplus bagasse as fuel.

It is a very promising way to give the cane sugar industry the opportunity to remain as an important economical component of sugar exporting countries.

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ÉVALUATION TECHNO-ÉCONOMIQUE D'UN COMPLEXE USINE A SUCRE-DISTILLERIE D'ÉTHANOL POUR LA PRISE DE DÉCISIONS POUR ASSURER LE REVENU FINANCIER OPTIMAL

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Résumé

LA PRODUCTION mondiale d'éthanol a connu une croissance rapide depuis le début de cette décennie, stimulée par son utilisation comme carburant une plus grande échelle. Par exemple, en 2001, 42% de la production mondiale d'éthanol a été utilisé par les boissons, les cosmétiques et l'industrie chimique, alors qu'en 2008, ce pourcentage n'est que de 20, les 80% restants étant utilisés comme carburant (bioéthanol). Aufait, la production de bioéthanol a passé de 18 milliards de litres en 2001 à une production estimée de 66 milliards litres en 2008. Cela signifie que l'éthanol est aujourd'hui le principal carburant liquide alternatif et sa production à partir de la canne à sucre est la seule source qui ne pose pas de danger pour l'alimentation et qui induit également une réduction significative de l'effet de serre. L'option technologique visant la production simultanée d'éthanol à partir de jus de canne, de sucre à pol très élevé (VHP) et la cogénération de l'électricité à partir de la bagasses de canne à sucre est très attrayante. Cette communication comporte une évaluation techno-économique, avec un modèle interactif qui peut guider la prise de décision dans le processus de rentabilité dans un ensemble industrielle usine de sucre-distillerie, pour obtenir un revenu optimal tenant compte les prix du sucre et de l'éthanol en cours sur les marchés mondiaux. Une étude de cas à Cuba est présentée.

EVALUACIÓN TÉCNICO-ECONÓMICA DE UN ESQUEMA INTERACTIVO DESTILERÍA-INGENIO AZUCARERO PARA GUIAR A LA TOMA DE DECISIONES PARA EL MEJOR BALANCE DE GANANCIAS

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Etanol, Cogeneración, Economía.

Resumen

LA PRODUCCIÓN mundial de etanol ha crecido rápidamente desde el inicio de la actual década, promovido por su mayor empleo como combustible. Por ejemplo, en el 2001 el 42% de la producción mundial de etanol se dirigía a las bebidas, cosméticos y la industria química, pero en el 2008 esta cifra descendió hasta solo el 20%, con el 80% empleado como combustible (bioetanol). De hecho, la producción de bioetanol creció de 18 000 millones de litros en el 2001 hasta un estimado de 60 000 millones de litros en el 2008. Esto significa que el etanol es hoy el principal combustible líquido alternativo y que el etanol obtenido de la caña de azúcar es la única fuente que no compromete fuentes alimenticias e induce una reducción significativa del efecto invernadero. La opción tecnológica de una producción combinada de etanol de los jugos de caña y azúcares de muy alto Pol (VHP), con una contribución adicional de bagazo sobrante para cogeneración eléctrica tiene un gran atractivo. Este artículo presenta una evaluación técnico-económica, con un modelo interactivo que puede dirigir el proceso de toma de decisiones en el Complejo Ingenio-Destilería de alcohol, para alcanzar el mejor balance de ganancias, en correspondencia con los precios prevalecientes en los mercados para el azúcar y el etano. Se presenta un 'Estudio de Caso' para un Complejo cubano.