COMMUNITIES AUTO SUFFICIENT IN FUELS FOR HUMANS, TRANSPORT AND ELECTRIC NEEDS

By

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Abstract

IN VIEW OF the present problems facing the world with respect to fossil fuels (pollution and global warming, availability and price), we studied the possibility of a small community becoming auto sufficient in sugar, automotive fuel (ethanol) and electricity, all from renewable biomass (sugarcane). The study was done, based on a real project that we are presently installing under similar lines. The fuel needs of a community of 100 000 people were quantified in terms of sugar, ethanol, and electricity. A mass and energy balance was calculated to determine the amounts of cane and trash needed to produce the sugar, ethanol and electricity by generation and co-generation. The results showed us that 100 tonnes of cane per hour can supply sufficient sugar and electric energy for a community of 100 000 people and run their cars on 96ºGL ethanol (no mix with gasoline) and still be able to export surplus ethanol. The auto sufficiency is for the whole year and not only the crop period. The overall results showed us that, when compared to the importation of 'fuels', the project was positive.

Introduction

The aim of this paper is to show how a relatively small sugar and ethanol factory with cogeneration (and straight generation) can provide all of the energy necessary to 'fuel' small communities with:

- Human fuel: sugar.
- Transport fuel: ethanol.
- Lighting and heating fuel: electricity.

The idea is to produce sugar and ethanol from mixed juice from sugarcane. The resulting molasses from the sugar production would go to ethanol production. To produce the electrical energy, we would burn all the bagasse and a part of the cane trash in a high pressure boiler.

To have electrical energy all year round (crop and off crop), we will show that we can divide the bagasse and trash for crop and off-crop generation.

Communities

To establish the amounts of 'energies' needed by the community, we have made the following assumptions in Table1:

Table 1—Assumptions used in the analysis.

Energy	Specific Quantity
Sugar	30 kg per person per year
Ethanol	1200 litres per vehicle per year
Electrical energy	200 kWh per home per month

If we assume a community of 100 000 people, and that, on average, there will be one house for every 4 people and 1 vehicle for every house, Table 2 shows the annual quantities:

Table 2—Annual quantities required.

Energy	Annual quantity
Sugar	30 kg x 100 000 = 3000 tonnes sugar
Ethanol	25 000 vehicles x 1200 = 30 000 000 L
Electrical energy	25 000 homes x 200 x 12 = 60 000 MWh

The electricity is the equivalent of ~ 6.9 MW.

Field and factory

To be able to take advantage of the trash, the cane cannot be burnt. The cane has to be machine harvested and a part be sent to the factory with the cane. This can be controlled by fans on the harvesters. The tops which will almost surely be green should be left in the field.

The amount of trash sent to the factory should be about 10% of the (clean) cane. That means that a fair amount of trash will still remain on the fields, which is good from the agronomic point of view.

At the factory, a cane/trash separation system must be used on the feed table or preferably on a carrier. The trash is separated by fans, when the cane falls from one carrier to another.

The separated trash will then be cleaned of its dirt (soil and sand) in a dry cleaning system (rotary screen). After cleaning, it must be shredded and sent to join the bagasse at the outlet of the mill.

Ideally, for high extraction and low maintenance costs, a diffuser would be better than mills.

The mixed juice is divided into two streams, one for sugar and the other for ethanol. The amounts of juice for each stream will of course depend on the amounts of sugar and ethanol to be produced.

Ideally, one of the streams would be preset and the other would receive the balance. The quantities for this specific project can be seen on Figure 2.

Preparation of the juice to be used for sugar production will be relatively conventional: clarifier and multiple effect evaporators.

As the amount of muds will be very small, they can be recycled to the diffuser, thus eliminating the filter station, and its associated losses.

In the boiling house, we will use just one boiling as the amount of sugar required will be very small as opposed to ethanol.

This gives us the added advantage of being able to make a very good quality sugar (raw or mill white) as there are no molasses boilings.

We will have a purity drop of about 15 points. All the molasses will go to the distillery with a purity of about 70º.

The second mixed juice stream will go directly to the fermentation without needing clarification. It has, however, to be well screened and heated and then cooled on arriving at the distillery. Diffuser juice is clean enough for fermentation.

Fermentation will take place with a mixture of juice and molasses. The fermented juice ‘must’ (beer/wine) will go on to the distillery where hydrous (96ºGL) ethanol will be produced.

Figure 1 shows the basic flow diagram of the plant.

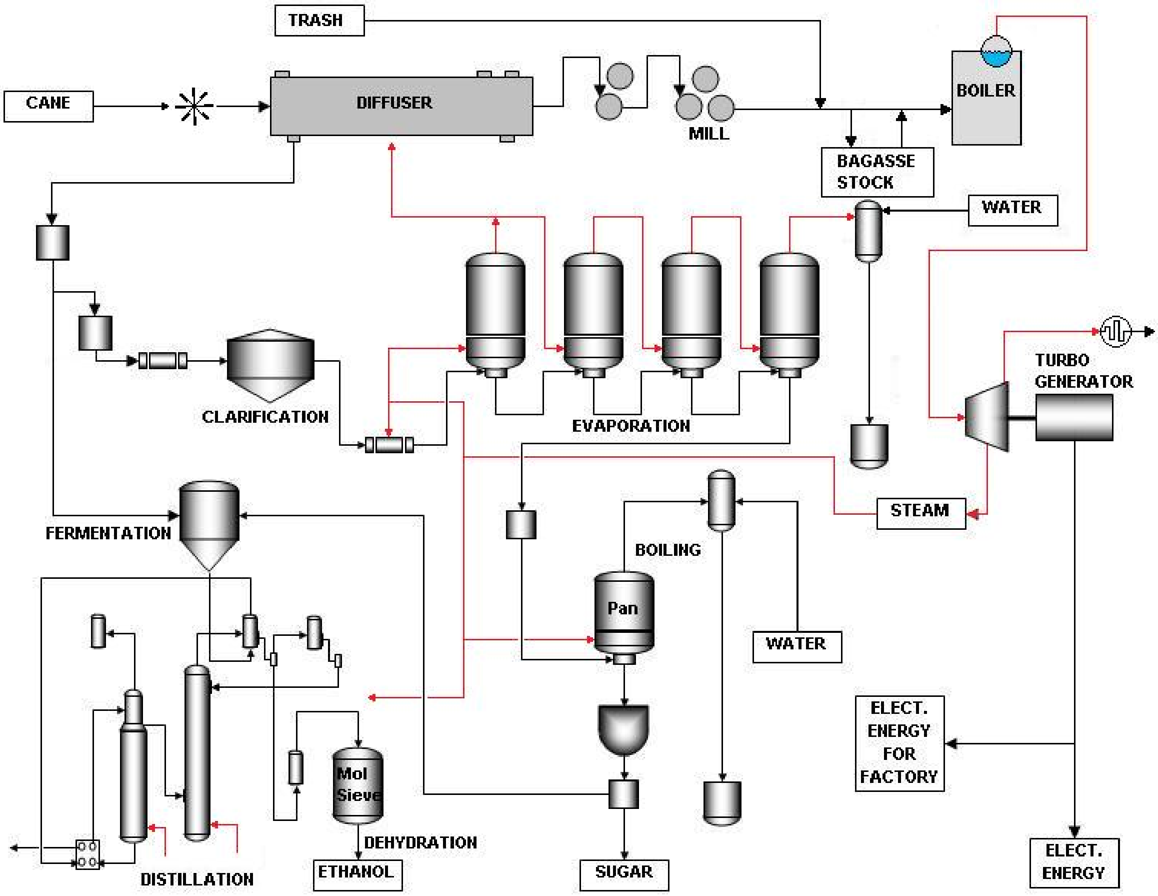

Fig. 1—Basic flow diagram of the plant.

The bagasse that leaves the mill after the diffuser receives the trash and then goes on to the boiler. At this point, part of the 'fuel' (bagasse + trash) can be divided, part being burnt and part stocked for off crop generation, or all can be burnt, thus generating more energy, but only during the crop.

A high pressure boiler must be used. For this simulation, we are considering a 65 bar pressure and super heated steam temperature of 480°C on arrival at the turbine.

In the case of burning all the fuel, a steam turbine with an exhaust extraction for process and an extraction direct to a condenser can be used. If generation is to be all year round, it would be preferable to have 2 turbines: a back pressure turbine and a condensing turbine.

If we consider:

- live steam at 65 bar and 480°C
- exhaust steam at 2.5 bar
- condenser steam at 0.1 bar

The specific steam consumption will be as follows in Table 3

Table 3—Specific steam consumption.

Steam	Specific steam consumption		
	From	To	Kg steam/kWh
Exhaust steam	65 bar	2.5 bar	5.4
Condenser steam	65 bar	0.1 bar	3.9

The plant will be totally electric. This fact plus the amount of water needed for the TG condenser, its cooling and the energy needed for the trash treatment will give us an electric energy consumption above that of a conventional steam driven factory.

Balances

Below are 3 balances (Figures 2, 3 and 4). In Figures 2 and 3 we have used a maximum of 500 kg process steam per tonne cane.

In fact, we know that this figure can come down to the range of 350 to 450, depending on what steam economy techniques are used.

The process steam consumers are the evaporation, diffusion and distillation and boiling. Distillation and boiling can be done with bleeding of first and second vapours. Primary heating of water and or juice can be done with vinasse.

Figure 2 shows a flow diagram and balance of a 100 tch plant burning all its fuel during the crop:

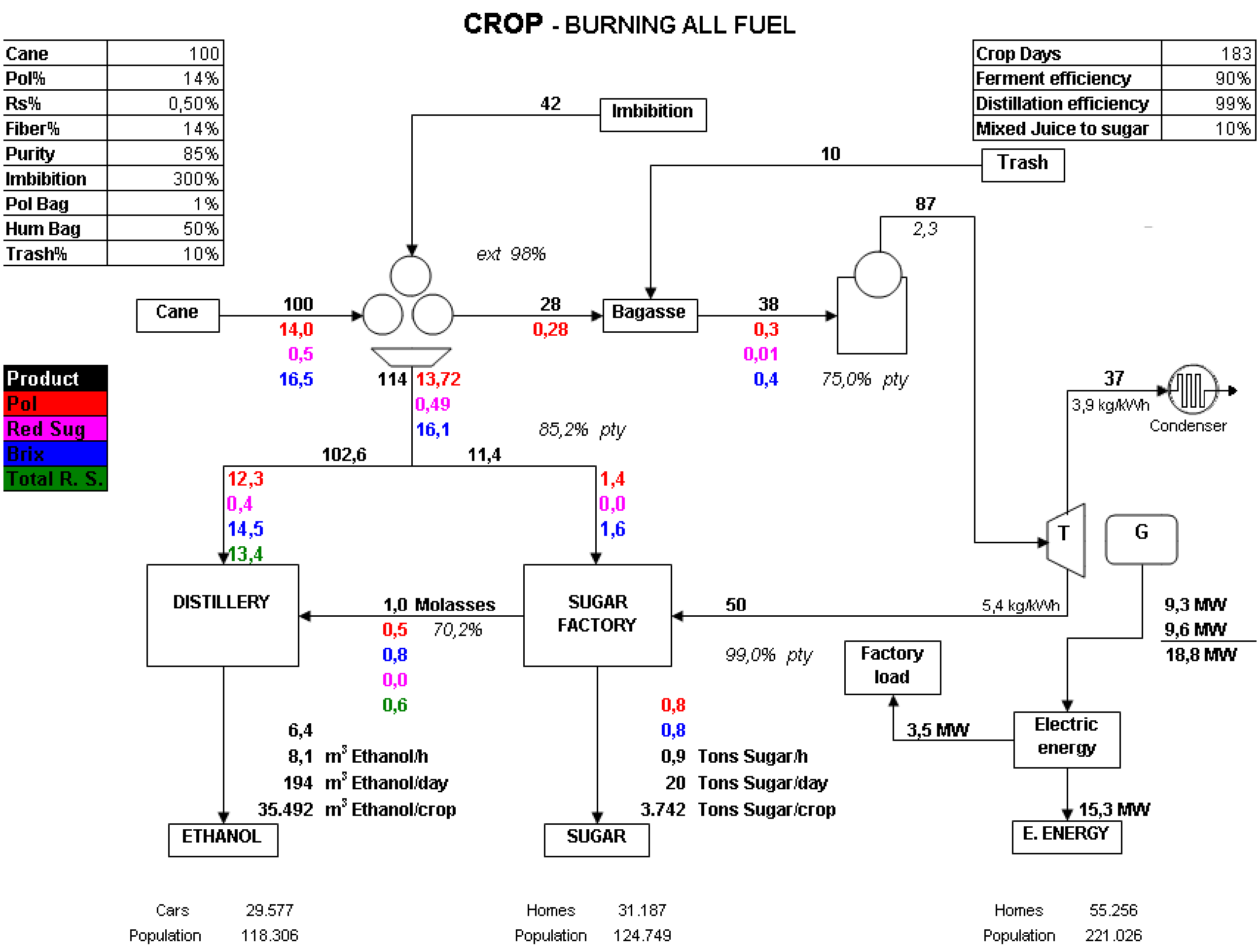

Fig. 2—Mass and energy balance of plant burning all its fuel during the crop period.

Figure 3 shows a flow diagram and balance of a 100 tch plant burning the amount of bagasse it needs to generate the steam necessary for the process during the crop, plus a small additional amount to reach the energy export necessity.

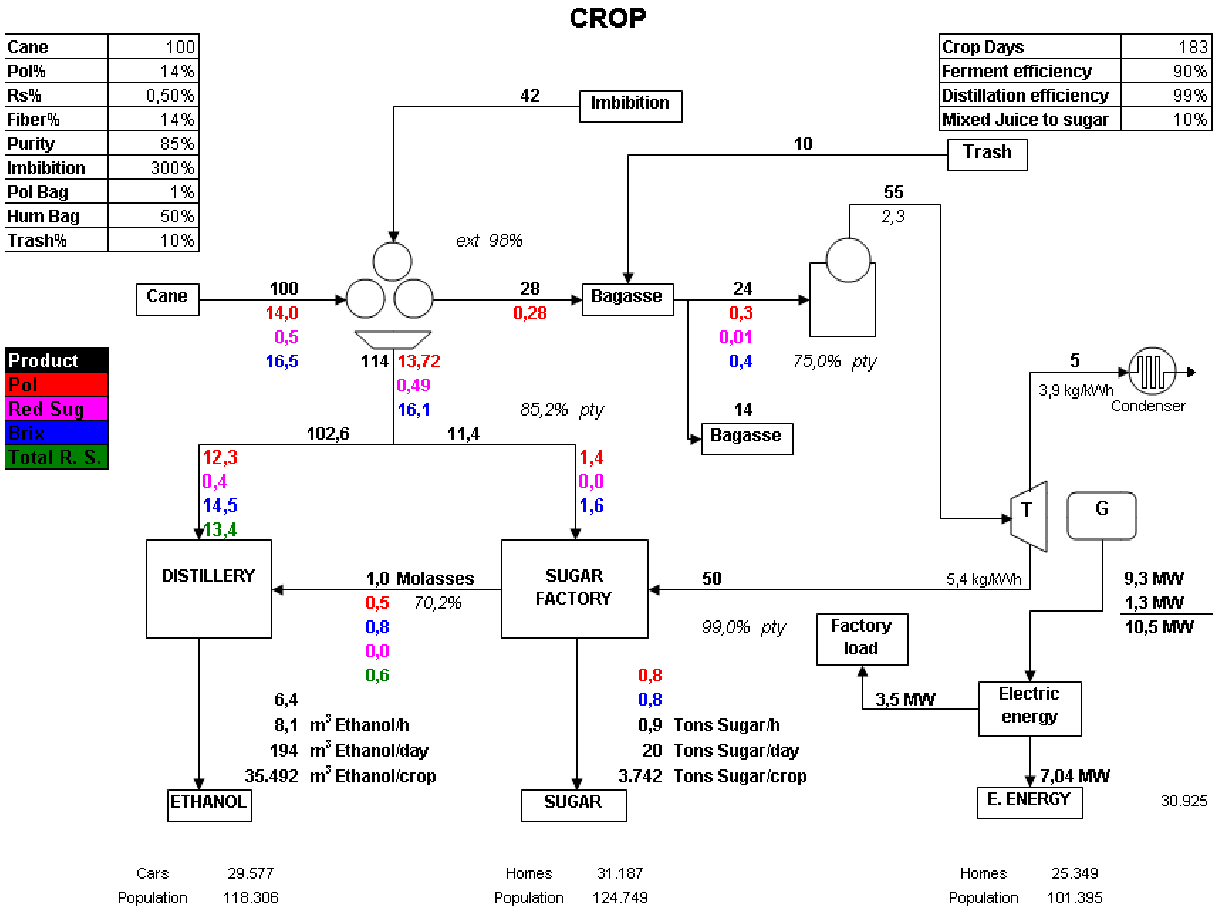

Fig. 3—Mass and energy balance of plant burning part of its fuel during the crop period.

Figure 4 shows a flow diagram and balance of the same 100 tch plant, during the off-crop, burning the fuel left over from the crop.

It must be remembered that our fuel is bagasse and trash. During the crop, the trash is mixed into the bagasse before it is either burned or stocked.

Therefore, we can assume that during the off crop we will be burning a mixture of bagasse and trash.

It can be seen that the amount of bagasse burnt per hour is less than what was burnt per hour during the crop, but the amount of exportable energy is more.

This is because all the steam goes directly down to condenser pressure (0.1 bar) and thus has a higher enthalpy drop. In this case, we have pure thermo electric generation and not co-generation.

Thus, even though the crop harvest lasts only six months, we are able to generate electricity all year round and in the same quantity.

The overall scheme, operating throughout the year, therefore, produces as presented in Table 4.

Table 4—Yearly production.

Production with 100 TCD				
	Production	Necessity	Extra	
Sugar tonnes	3742	3000	742	19.83%
Ethanol m^3	35 492	30 000	5492	15.47%
Electricity MW	7.00	6.90	0.10	1.43%

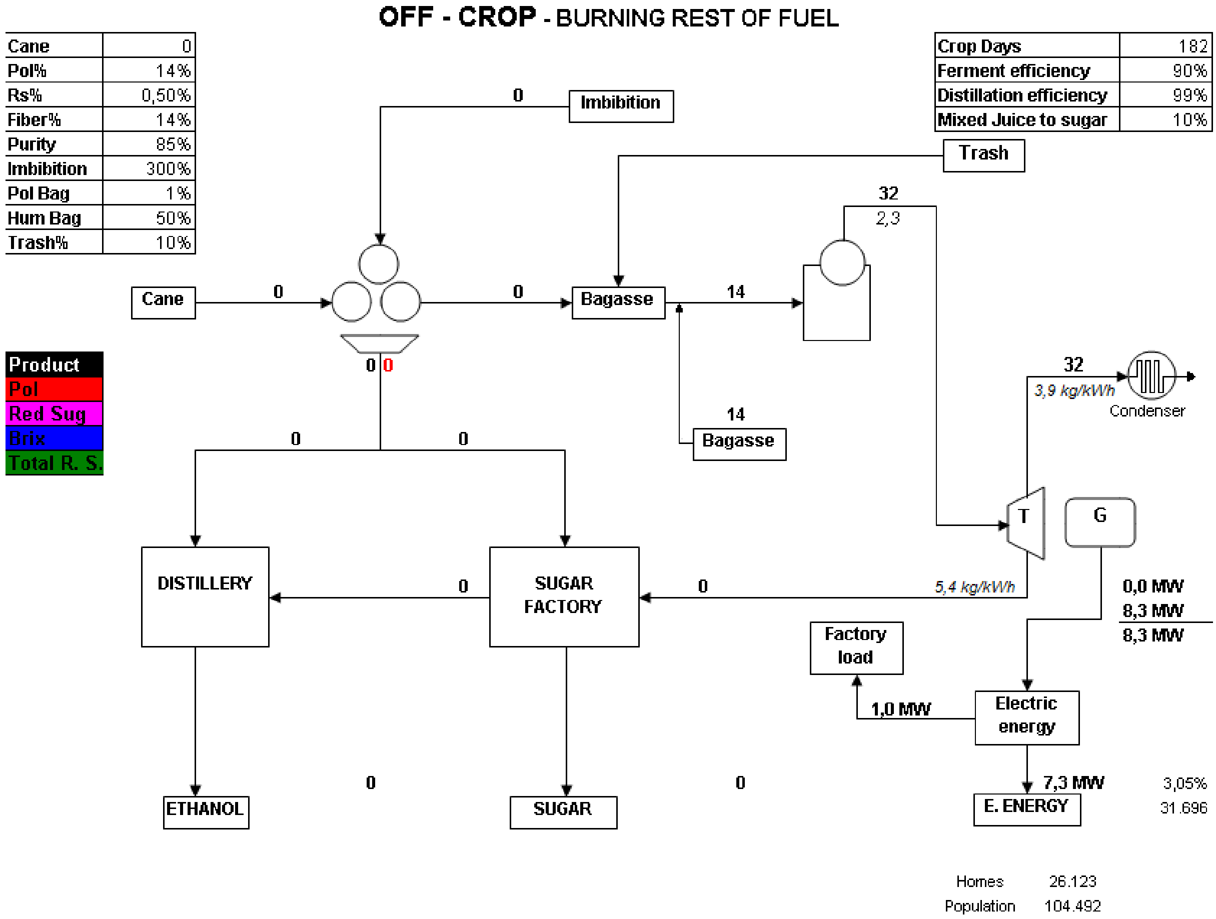

Fig. 4—Mass and energy balance of plant burning its stocked fuel during the off-crop period.

It can be seen that we have a 19% excess of sugar and a 14% excess of ethanol. These products can be exported or sold to hotels, hospitals etc.

From these figures, we can now draw up a Table for various sizes of communities (Table 5).

Table 5—Figures for different size communities.

Cane		Population	Houses	Vehicles	Sugar	Ethanol	Electricity
TCD	TCH				Tonnes	m^3	MW
1 200	50	50 000	12 500	12 500	1871	17 746	3.50
2 400	100	100 000	25 000	25 000	3742	35 492	7.00
3 600	150	150 000	37 500	37 500	5613	53 239	10.50
4 800	200	200 000	50 000	50 000	7484	70 985	14.00
6 000	250	250 000	62 500	62 500	9355	88 731	17.50
7 200	300	300 000	75 000	75 000	11 226	106 477	21.00
8 400	350	350 000	87 500	87 500	13 097	124 224	24.50
9 600	400	400 000	100 000	100 000	14 968	141 970	28.00
10 800	450	450 000	112 500	112 500	16 839	159 716	31.50
12 000	500	500 000	125 000	125 000	18 710	177 462	35.00

Conclusion

We have shown two possible scenarios:

- Producing sugar, ethanol and electric energy burning all the fuel (bagasse and trash).

This option would be ideal in places where it is possible to run the plant all year round. An example of this is Peru where, in the absence of rain, they are obliged to irrigate in desert lands. The advantage is that they can operate all year round.

- Producing sugar, ethanol and electric energy burning only part of the fuel during the crop, and the rest during the off crop to continue electric energy production.

In this case, the exportable electric energy production is about half of that in the first case, but over a longer period [assuming a six month harvest season].

If we assume an agricultural productivity of 80 tonnes cane per hectare and a harvest period of 180 days, it would be necessary to have:

100 × 24 × 180 = 432 000 tonnes cane

432 000 / 80 = 5400 ha

Assuming a plant crop and 4 ratoons, we need to increase the land by 20%: 6480 ha

Therefore, with 6480 ha of land and sufficient rainfall, it is possible to supply a community of 100 000 with all their sugar, electricity and automotive fuel (pure hydrous ethanol with no gasoline mixture)

This industry would create jobs (factory and field) and still save money on imported fuel (oil/gasoline/diesel). This money could be recirculated within the community or used for importation on other needed goods.

An estimated cost of such an industry of this size (100 tonnes cane/hour) is US$70 000 000 installed. The cost of the field side would depend on other non technical factors, but we could say its cost would be similar to that of the factory. Therefore, such an agro-industry could be implemented for about US$140 000 000.

Many small countries/islands spend this or more per year importing oil. At US$100/barrel, this is equivalent to a consumption of about 4000 barrels per day.

Perhaps on a medium to long-term basis the most important message here is that:

MOST OR ALL THE CO_2 PRODUCED IS RECYCLED.

COMMUNAUTÉS AUTOSUFFISANT EN CARBURANT POUR LES BESOINS DE L'HOMME, LE TRANSPORT ET L'ÉNERGIE ÉLECTRIQUE

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MOTS-CLÉS: Sucre, éthanol, Co-generation.

Résumé

COMPTE tenu des problèmes actuels auxquels le monde fait face par rapport à des combustibles fossiles (la pollution et le réchauffement planétaire, disponibilité et prix), nous avons étudié la possibilité qu'une petite communauté devienne autosuffisante en sucre, en carburant automobile (éthanol) et en électricité, cela à partir de la biomasse renouvelable (la canne à sucre). L'étude faite, a été basée sur un véritable projet que nous mettons en route actuellement dans un cas similaire. Les besoins en carburant d'une communauté de 100 000 personnes ont été quantifiés en termes de sucre, d'éthanol et d'électricité. Un bilan de masse et de l'énergie a été calculé pour déterminer la quantité de canne à sucre et de pailles nécessaire pour produire le sucre, l'éthanol et l'électricité par cogénération. Les résultats ont démontré que 100 tonnes de canne par heure peuvent fournir suffisamment de sucre et de l'énergie électrique pour une communauté de 100 000 personnes et rouler leurs voitures entièrement sur l'éthanol et de surcroît être en mesure d'exporter un surplus d'éthanol. L'autosuffisance est pour l'ensemble de l'année et pas seulement pendant la période de récolte. Les résultats ont démontré que, par rapport à l'importation de "combustibles", le projet a été positif.

COMUNIDADES AUTO SUFICIENTES EN COMBUSTIBLES PARA LAS NECESIDADES HUMANAS, DE TRANSPORTE Y ELÉCTRICAS

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PALABRAS CLAVE: Azúcar, Etanol, Cogeneración.

Resumen

EN VISTA de los presentes problemas que el mundo enfrenta en relación con los combustibles fósiles contaminación y calentamiento global, disponibilidad y precios) estudiamos la posibilidad de una pequeña comunidad convertida en autosuficiente en azúcar, combustible automotor (etanol) y electricidad, todo a partir de la biomasa renovable (caña de azúcar). El estudio se realizó en un proyecto real que estamos instalando actualmente bajo similares líneas. El combustible necesario para una comunidad de 100 000 personas se cuantificaron en términos de azúcar, etanol y electricidad. Se calculó un balance de masa y energía para determinar las cantidades de caña y paja necesarias para producir el azúcar, el etanol y la electricidad por generación. Los resultados nos mostraron que 100 toneladas métricas de caña por hora puede suministrar suficiente azúcar y energía eléctrica para una comunidad de 100 000 personas y abastecer sus autos con etanol (sin mezcla) y aún ser capaces de exportar etanol sobrante. La autosuficiencia es para un año completo y no solo para el período de zafra. Los resultados totales nos mostraron que cuando se compara con la importación de combustibles era positivo.