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BE-Basic Foundation

Biorefinery options for sugarcane processing in Brazil.

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Introduction

For the production of biobased products and bioenergy is the utilization of integrated biorefinery systems a crucial element. Many different conversion pathways and potential end products have been proposed, however, their economic performance and GHG emission intensity, especially in relation to the fossil counterpart is often unclear or not uniformly defined. **The aim of this research is determine the economic performance and GHG emission intensity of different biorefinery products from the processing of sugarcane in Brazil.**

Approach

To assess the economic performance and GHG emission intensity the approach include 1) selecting final biobased product and required conversion steps, 2) calculating the mass balance of the involved conversion processes in the biorefinery plant, 3) determining net present value (NPV) and minimum product selling price of the biorefinery project or final product(s), and 4) calculating the GHG emission intensity of the final product(s). Scientific publications and expert opinions are used to determine the conversion ratios, capital and operational costs and the GHG emissions for sugarcane supply and during the different conversion steps.

Selected final products are:

Ethanol:

$$2C_6H_{12}O_6 = \mathbf{2C_2H_6O} + CO_2$$

Ethylene:

$$C_2H_6O = \mathbf{C_2H_4} + H_2O$$

Succinic acid:

$$7C_6H_{12}O_6 + 6CO_2 = \mathbf{12C_4H_6O_4} + 6H_2O \text{ or}$$
$$7C_5H_{10}O_5 + 5CO_2 = \mathbf{10C_4H_6O_4} + 5H_2O$$

1.3 Propanediol:

$$C_6H_{12}O_6 + 0{,}18O_2 = \mathbf{1{,}45C_3H_8O_2} + 1{,}64CO_2 + 0{,}18H_2O$$

Box 1 Selected final products and production pathways

Results

In Figure 1, the economic performance of the nine different biorefinery configurations is shown, expressed as US$$_{2014}$$ per tonne sugarcane feedstock. The revenues of the final product dictate the net present value, especially for the configurations which produce succinic acid. Higher capital investment costs for a biorefinery producing succinic acid from sugar juice and sugarcane bagasse is offset by the higher succinic acid yield and subsequent higher revenues.

The GHG emission balance is dominated by the avoided GHG emissions due to avoided use of fossil counterparts. Especially the avoided GHG emissions with PDO production from sugarcane are high.

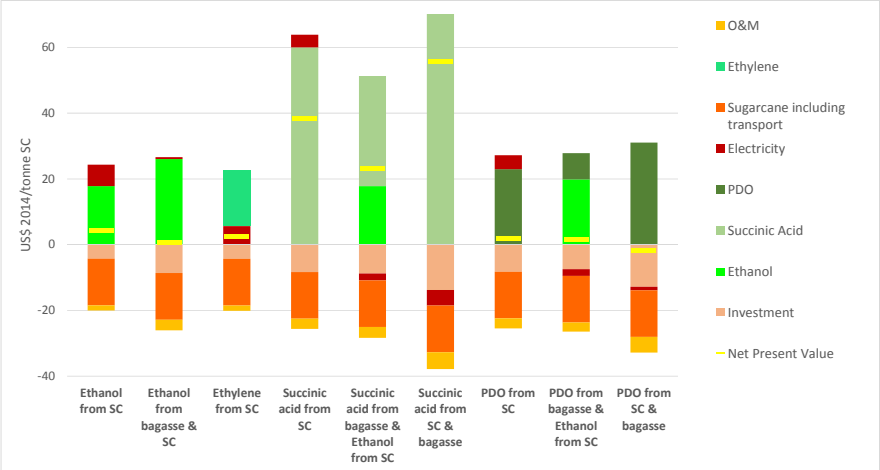

Figure 1. Net present value of different biorefinery configurations, expressed in US$2014 per tonne sugarcane

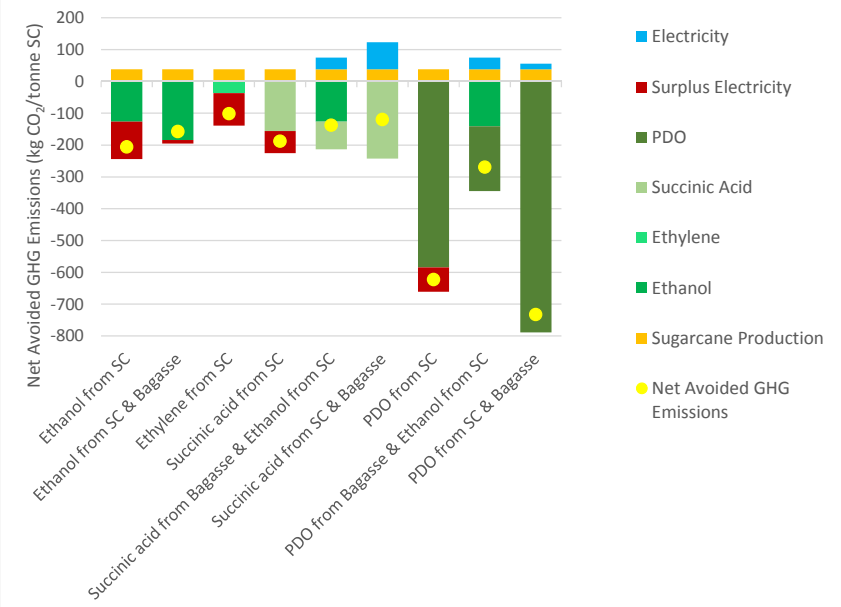

Figure 2. Net GHG emission balance of the different biorefinery configurations, expressed in kg CO_2 per tonne sugarcane.

Discussion and conclusion

Key assumptions that drive the results are the biobased product revenues and GHG emissions avoided due to product substitution. When performing a detailed techno-economic analysis the lack of harmonize data was one of the biggest challenges of this research.

Due to the high product revenues, the configuration with succinic acid production has the highest economic revenues. The largest avoided GHG emissions are achievement with PDO production. However, this biorefinery configuration is in very early stage of development.

More research is required on operational yield of the different biobased chemicals using sugarcane and sugarcane bagasse as feedstock. Furthermore, more research is required on the costs and GHG emissions of the different conversion steps.

This work was carried out within the BE-Basic R&D Program, which was granted a FES subsidy from the Dutch Ministry of Economic affairs, agriculture and innovation (EL&I). This project was co-funded by the FAPESP Bioenergy Program – BIOEN.

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