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Techno-Economic Assessments of Promising Chemicals from a Sugar Mill Based Biorefinery

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Abstract : Lignocellulose can be converted to a range of biochemicals and biofuels. Where this is derived from agricultural waste, issues of competition with food are virtually eliminated. One such source of lignocellulose is the South African sugar industry. Lignocellulose could be accessed by changes to the current farming practices and investments in more efficient boilers. The South African sugar industry is struggling due to falling sugar prices and increasing costs and it is proposed that annexing a biorefinery to a sugar mill will broaden the product range and improve viability. Process simulations of the selected chemicals were generated using Aspen Plus®. It was envisaged that a biorefinery would be annexed to a typical South African sugar mill. Bagasse would be diverted from the existing boilers to the biorefinery and mixed with harvest residues. This biomass would provide the feedstock for the biorefinery and the process energy for the biorefinery and sugar mill. Thus, in all scenarios a portion of the biomass was diverted to a new efficient combined heat and power plant (CHP). The Aspen Plus® simulations provided the mass and energy balance data to carry out an economic assessment of each scenarios. The net present value (NPV), internal rate of return (IRR) and minimum selling price (MSP) was calculated for each scenario. As a starting point scenarios were generated to investigate the production of ethanol, ethanol and lactic acid, ethanol and furfural, butanol, methanol, and Fischer-Tropsch syncrude. The bypass to the CHP plant is a useful indicator of the energy demands of the chemical processes. An iterative approach was used to identify a suitable bypass because increasing this value had the combined effect of increasing the amount of energy available and reducing the capacity of the chemical plant. Bypass values ranged from 30% for syncrude production to 50% for combined ethanol and furfural production. A hurdle rate of 15.7% was selected for the IRR. The butanol, combined ethanol and furfural, or the Fischer-Tropsch syncrude scenarios are unsuitable for investment with IRRs of 4.8%, 7.5% and 11.5% respectively. This provides valuable insights into research opportunities. For example furfural from sugarcane bagasse is an established process although the integration of furfural production with ethanol is less well understood. The IRR for the ethanol scenario was 14.7%, which is below the investment criteria, but given the technological maturity it may still be considered for investment. The scenarios which met the investment criteria were the combined ethanol and lactic acid, and the methanol scenarios with IRRs of 20.5% and 16.7%, respectively. These assessments show that the production of biochemicals from lignocellulose can be commercially viable. In addition, this assessment have provided valuable insights for research to improve the commercial viability of additional chemicals and scenarios. This has led to further assessments of the production of itaconic acid, succinic acid, citric acid, xylitol, polyhydroxybutyrate, polyethylene, glucaric acid and glutamic acid.

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