Utility Integrated Biorefineries*

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Executive Summary

This report describes how capacity planning models can be used to plan investments in biorefineries. For this, we have considered several processes belonging to a chemical supply chain that can be fed by a raw material, such as switchgrass, and used to produce valuable commodities. To build our model we have considered 58 possible processes to choose from, part of which are 12 chemicals chosen by the U.S. Department of Energy for production of value-added chemicals from biomass. The model maximizes net present value, considers budgeting conditions to self-finance expansions and determines what process ought to be constructed in the biorefinery, initial process capacity, as well as construction time and the timing and size of future expansions. Projected raw material availability, market projected demand and prices, as well as transportation costs are included. Among other results, the model is also able to provide the location of the refinery based on market demand and proximity to feed. All these features notwithstanding, integration of centralized utilities was analyzed to determine the optimal value added chain of processes, a feature that has not been considered in any previous models. Using the capacity planning model, processes were systematically eliminated from the initial 58 processes through systematic screening involving costs within the biorefinery. The screening gives the best combination of processes to maximize the profitability of the biorefinery. The final process flow chart included only three processes, each of which produces a high-priced value added chemical. Out of the three processes, two are fermentation-based, producing 3-Hydroxypropionic acid and Glucaric Acid. The third process produces 5-hydroxymethyl furfural through decomposition of glucose. The model also determined the best time to build and expand these processes. Under the current conditions, the model determined that all processes should be built immediately with no expansions during the twenty year lifetime. These processes were chosen not only on the basis of final product selling cost, but also on the lower operating costs compared with other processes. The model also determined the minimum capital investment required to carry out the start-up from a given amount of available money for investment. Assuming $250 million investment available, the results for centralized and non-centralized utilities differ significantly. The net present value for the integrated model was $621 million with a return on investment of 14% after 20 years. For the non-integrated model the net present value was $151 million with a return on investment of 3%. It is concluded that integration of utilities indeed does increase profitability. The model also chose the optimal location for the biorefinery, as well as switchgrass farm location and markets for sales of products. The biorefinery should be located in Huntsville, AL with raw materials also purchased from Alabama. The final products are sold in Chicago, IL and Houston, TX.