INTEGRATED PROCESS, FINANCIAL, AND RISK MODELING OF EMERGING BIOENERGY PRODUCTION TECHNOLOGIES: METHODOLOGY AND EXAMPLES

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As researchers and engineers propose new pathways to convert lignocellulosic feedstock to useful chemicals and products, it is critical that tools and methodologies be available to evaluate these technologies and identify which combinations (feedstock and conversion pathway) are both technically and economically feasible. To understand the integrated economics and viability of a particular renewable conversion technology, a research group must marry technical and scientific knowledge with modeling tools to examine the complete picture of bioenergy from raw material growth and harvesting, to process simulation, to financial investment modeling. Examining each one of these areas independently does not provide a clear picture of the techno-economic viability.

A systematic approach for modeling biomass production, processes, and financial/risk forecast has been developed using commercially available modeling and simulation packages populated by original research and literature data. A brief discussion of this methodology will be followed by a discourse of case studies completed using this approach. The case studies that will be discussed include: "Cellulosic Ethanol Production in a Repurposed Kraft Pulp Mill", "Co-production of Electricity and Ethanol, Process Economics of Value Prior Combustion", and "Economic and Risk Modeling of Cellulosic Ethanol from Woody and Non-wood biomass via Dilute Acid Pretreatment".

The repurposed kraft mill study found that producing cellulosic ethanol from green liquor pretreated hardwoods is potentially profitable with a minimum ethanol revenue ($MER_{@12\%}$) of $0.68/liter to achieve a 12% internal rate of return (IRR).

Value prior combustion (VPC) involves autohydrolysis of wood, and hemicellulose fermentation, before wood is burned to produce electricity. A $MER_{@12\%}$ of $0.84/liter for hardwood and $0.74/liter for softwood is estimated. The VPC technology model was subjected to a biomass cost sensitivity analysis using recent price distribution data and @Risk software to determine the probability of financial success. The risk analysis indicates ~27% probability of achieving an IRR greater than 12% assuming $0.65/liter ethanol revenue.

When evaluating woody and non-wood biomass processed via dilute acid pretreatment it was found that non-wood biomass had a lower $MER_{@12\%}$, $0.51-$0.77/liter, compared with the woody biomass, $0.82-$2.26/liter. The risk analysis of this technology and feedstocks indicates that financial success is generally driven by ethanol revenue, biomass cost, and ethanol yield

although loblolly pine is especially sensitive to electricity whole sale price due to low ethanol yield and high excess electrical power production.