*BIO-BUTANOL PRODUCTION AND SUPPLY CHAIN ECONOMICS*

Paul Bergey, North Carolina State University, Phone (919) 515-6949, Email: Paul\_Bergey@ncsu.edu
Geoff Parker, Tulane University, Phone (504) 865-5472, Email:gparker@tulane.edu

**Overview**
In an era of increasing price volatility and concerns over global warming, diversifying the energy supply base through reducing dependence on foreign oil and expanding domestic sources of environmentally friendly alternative energy sources have become pressing national priorities. One potential step toward this diversification is to expand the role of biofuels industry in the US economy. Before expanding existing ethanol programs, however, we suggest that there might be superior alternatives such as biobutanol.

Biobutanol is an alcohol-based biofuel that has many advantages over ethanol. Among the notable benefits of biobutanol are as follows. 1. It has a higher energy density per unit volume than ethanol. 2. It can be produced with significantly less energy than ethanol. 3. It is compatible with the existing distribution infrastructure for petroleum based fuels, and thus, can be distributed via the national pipeline network, unlike ethanol. 4. It is highly resistant to moisture absorption and therefore has potential as an aviation fuel. 5. It can be burned in existing automobile engines in any blended proportion (up to 100%) without significant performance degradation or engine modification. 6. It is cleaner burning than gasoline or ethanol and therefore yields a reduction in carbon emissions when consumed.

We are concerned that policy makers are moving forward with the build out of an ethanol infrastructure without a complete understanding of the impact of long term decisions. We posit that without proper studies there is a risk of being locked into an inferior market design which will be costly to change and the true social benefits from this emerging technology will not be fully realized. To this end, we examine the commercial/economic viability of the large scale production of biobutanol, first as an industrial solvent, second as a fuel additive, and third as a potential replacement for gasoline. Specifically, we attempt to quantify the risks venture capitalists face in their investment decisions and speculate on future policy decisions that may affect their choice to participate. We also examine the domestic labor benefits and potential environmental impact of this emerging biobutanol industry.

**Methods**Monte-Carlo Simulation

**Results**To attract private capital investment, we have developed a high level simulation model to characterize the investment risks for market participants interested in engaging in the emerging biobutanol industry. Using actual data that we have collected from the Reuters commodity trading system, we have constructed a preliminary monte-carlo simulation of price spreads between ethanol and conventional gasoline. Using ethanol price levels and correlations as a proxy for other biofuels such as butanol, we calibrated our simulation model to provide an estimate for a free market equilibrium price of carbon emissions for fossil fuels vs biofuels. We then examined the impact of incremental movements in the blend wall beyond 10%. Our cost estimation method is based upon the displacement volume of conventional gasoline with biofuels and the corresponding reduction in carbon footprint of the target biofuel as determined by the GREET model for life cycle analysis of carbon emissions, the government standard for carbon footprint analysis. Our preliminary model shows that a policy change moving the blend wall for reformulated gasoline from 10% (ethanol) to 20% (10% ethanol, 10% butanol), would displace approximately 11 billion gallons of conventional gasoline and result in a reduction of 3.6 to 14.3 million tons of greenhouse gas emissions per year. The expected costs of this change would be a price spread of approximately 23% between conventional gasoline and the biofuel alternatives, reflecting a free market price of mitigated carbon emissions of approximately $18.5 per ton CO2.

Using data from the first edition of the Biomass Energy Databook, we have constructed a preliminary model for estimating the number of new plant jobs created and the number of supply chain jobs supported by the startup (or conversion) of a corn ethanol plant to a biobutanol plant. A movement of the blend wall in reformulated gasoline from 10% (ethanol) to 12.35% (10% ethanol, 2.35% butanol), could be achieved by retrofitting the 24 idle ethanol plants taken out of service in the past three months (2 billion gallons per year capacity), , which would save between 135,000 to 142,000 supply chain jobs and create an estimated 8,000 new butanol plant jobs, while simultaneously serving our environment and reducing our dependency on foreign oil.

**Conclusions**Preliminary results suggest that the investment risk for a startup biobutanol plant is high. Policy decisions such as the introduction of a carbon tax or a cap & trade system would mitigate the risk. Large scale production of biobutanol (in lieu of ethanol) would likely have a positive impact on the environment, particularly with regard to reduced carbon emissions in the supply chain. A key factor to improving the environmental benefit of butanol over ethanol lies with scientific advancement of the production processes, whereby the percentage of acetone produced as a co-product is reduced.

**References**

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