Gasification-Based Ammonia Ethanol Production Model

Traditional production of ammonia has used natural gas as the energy and hydrogen feedstock for capturing nitrogen from the air and binding it to hydrogen atoms from the natural gas. Because Minnesota has no sources of natural gas, nitrogen fertilizers have been imported from other areas of the country or internationally. This sends roughly $400 million out-of-state each year to purchase nitrogen fertilizers. Minnesota does have alternative energy sources that may be able to substitute for natural gas in the production of fertilizers. One of these is residues from cropping, which can be converted to synthetic gas that can be used in place of natural gas for ammonia production.

This project examines the potential of using Minnesota-grown crop residues via gasification to make ammonia fertilizers. In addition to producing fertilizer, this gasification system would generate significant amounts of heat energy which would be available for other uses. The model that we've developed for our project examines ammonia-based gasification production at a co-located ethanol production facility. This would allow energy from the ammonia production system to substitute for heat made with natural gas that is needed for ethanol production. In addition to the increased efficiency of having the two plants located next to each other, it also increases opportunities for farmers to deliver farm-based products to the market.

Informally called a nitrofinery, this integrated facility was modeled using a number of estimates covering farm operations, ethanol plant production, and gasification/ammonia production data. Using these assumptions, the model examined the technical and economic viability of designing a nitrofinery.

Ethanol Production Assumptions (GREET 2014)		
Corn ethanol yield	2.82	gal/bu
Energy use at plant (Total)	26,000	Btu/gal
Natural gas	24,000	Btu/gal
Electricity use	0.75	kWh/gal
Co-product yield		
DGS	15	dry lb/bu
Corn oil	0.53	dry lb/bu

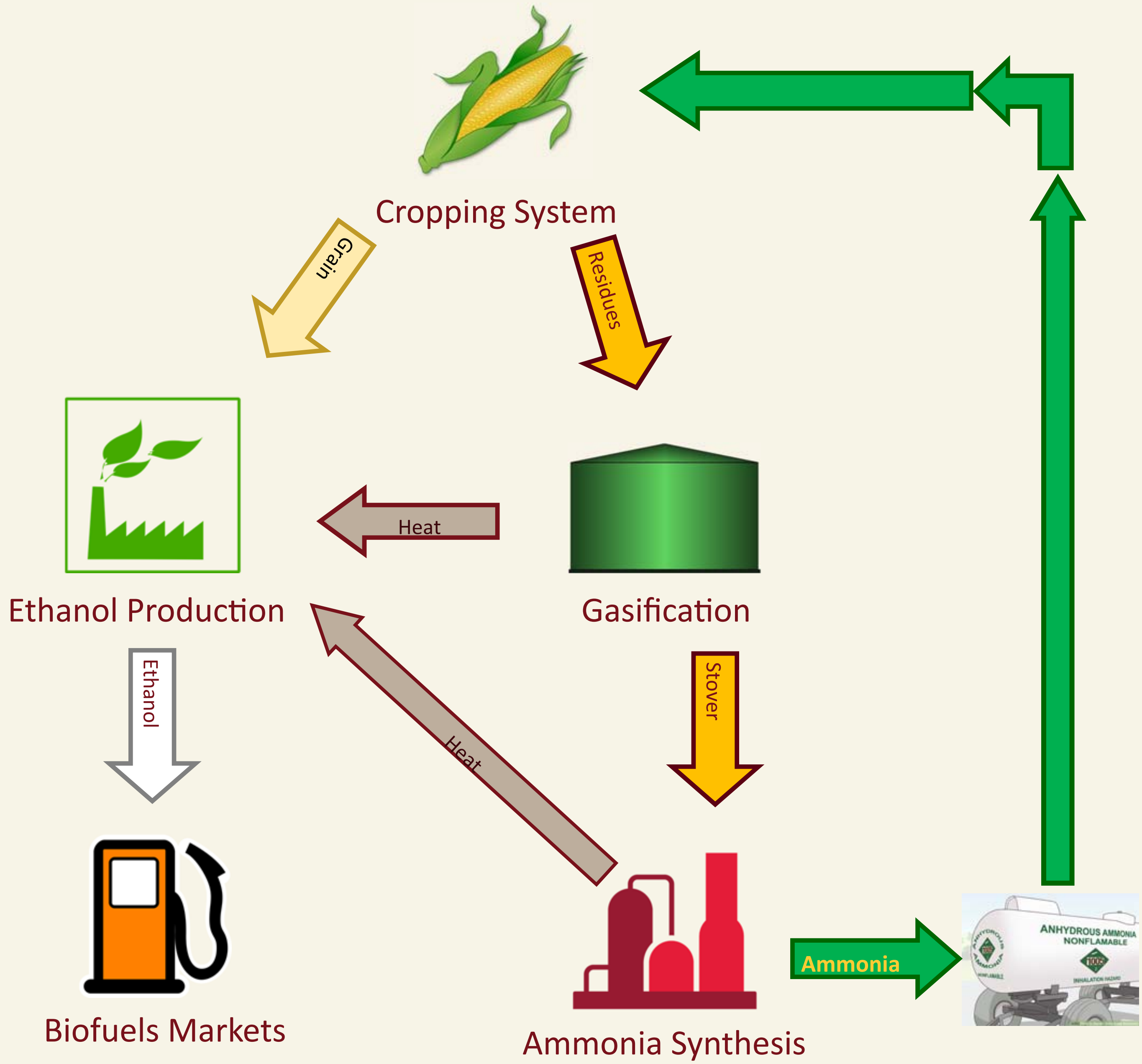
Process Mass Flows		
In		
Corn	506,800	Metric ton/yr
Corn cobs	422,400	Metric ton/yr
Out		
Ethanol	173,200	Metric ton/yr
DDGS	167,000	Metric ton/yr
Ammonia	166,700	Metric ton/yr

Grain and Biomass Inputs		
Corn	19,950,725	bu/yr
Corn cobs	465,612	tons/yr
Corn Grain Harvesting	142,431	acres/yr
Corn Cob Harvesting	791,411	acres/yr
Ammonia in grain cultivation	11,041	tons/yr

University of Minnesota
Driven to Discover℠

West Central Research & Outreach Center
46352 State Hwy 329 Morris, MN 56267
Phone: (320) 589-1711
Web: renewables.morris.umn.edu

Ammonia and Ethanol Production With Gasification



Overview of the Nitrofinery Model- The feedstock for both the ethanol and gasification process starts with the corn cropping system, grain is harvested and goes to the ethanol production facility. Corncobs are harvested and used in the gasification process. The corncobs are gasified to release methane, carbon monoxide, and hydrogen. These go on to be part of the ammonia synthesis process. In addition, heat is produced which can be used in the ethanol production process. Ammonia production uses steam methane reforming of the synthesis gases from gasification. In addition to the ammonia, additional heat is produced which can go to ethanol production. The ammonia produced can then be used in crop production, thus reducing the amount of imported anhydrous ammonia fertilizer.

Project Economics

The current low cost of natural gas has significantly reduce the price of conventional anhydrous ammonia from where it was seven or eight years ago. Therefore, the economics of this smaller scale production are not currently viable. This could significantly change if ammonia prices returned to their previous higher levels. Another potential future incentive may be the environmental benefits of producing a 'green' renewable based ammonia. However for the moment, the system is not economically feasible.

The two primary costs for the system are the purchase of biomass and capital costs for building the biomass gasification and ammonia production system. It was assumed that ethanol production facility would be existing with only minor modifications and that auxiliary costs included in the facility would cover the additional would cover integration. It was assumed the ethanol facility operation would not be substantially impacted by the ammonia production system, with the exception of supplying heat.

Expenses

Capital Costs.	
Base module cost	$82,000,000
Contingency	$15,000,000
Total module cost	$97,000,000
Total plant cost	$130,000,000
Auxiliary	$20,000,000
Depreciation (years)	15
Interest rate	10%
Total investment	$150,000,000

Operating Costs	
Biomass	Varies
Power	$3,200,000
Depreciation	$20,000,000
Total yearly expenditure	$28,000,000

Cob Purchasing	
Metric Tons /yr	422,400
@ $60	$27,936,945
@ 70	$32,593,102
@ 80	$37,249,260

Income and Potential Profit

Ammonia sales	Varies
Yearly earnings *	$20,700,000

* this number is fairly rough and does not take into account all added labor and costs.

Ammonia Sales	
Metric tons/yr	166,720
@ $300	$55,132,637
@ 500	$91,888,562
@ 700	$128,643,986

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Questions To Help Guide Discussions

General Questions

What level of need do you see for having local nitrogen fertilizer production? Currently? Future?

Is the environmental impact of the fertilizer used in agriculture important?
(Nitrogen fertilizer is roughly 35% of greenhouse gas footprint of corn)

Do the model assumptions look valid?

Overall ethanol conversion rates?

Biomass? Ability to contract biomass harvesting?

Economics

How much labor or added workers would this type of facility require?

Would hiring labor be a benefit to the project, or a problem?
(mostly labor for biomass harvesting)

What sort of return on investment would be expected.?

Interest by farmers and/or coop members

Will farmers/owners be interested in adopting the technology?

Would the complexity of the technology deter from investing in the technologies?

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