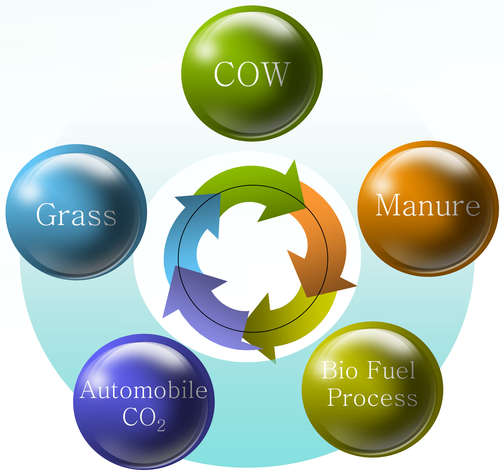
INTERPROFESSIONAL PROJECT

Design and Economic Evaluations of BIO REFINERY OPERATIONS

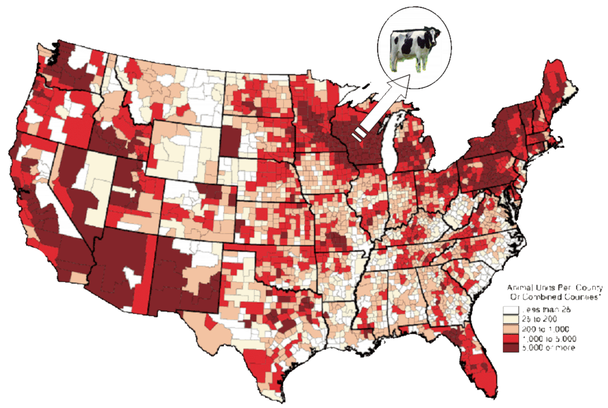
IPRO 347

ILLINOIS INSTITUTE OF TECHNOLOGY

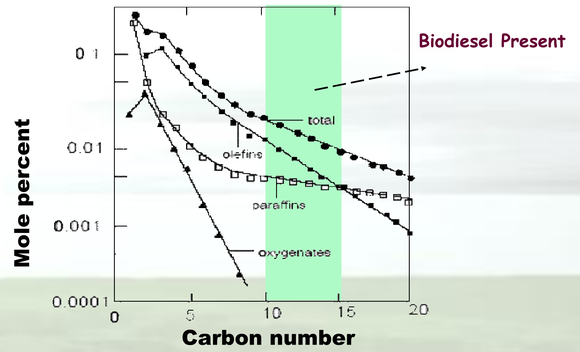


Mission

The objective of this IPRO is to design a chemical process which converts a biomass feedstock to liquid fuels which can be used for transportation. Deliverables include background research about existing similar processes and the need for such a project, a HYSYS flowsheet with all unit necessary operations, and a preliminary costing analysis to provide an initial estimate the cost of the fuel per gallon.

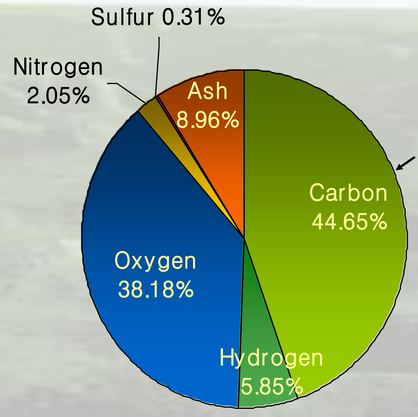


Typical Fischer-Tropsch liquid product distribution

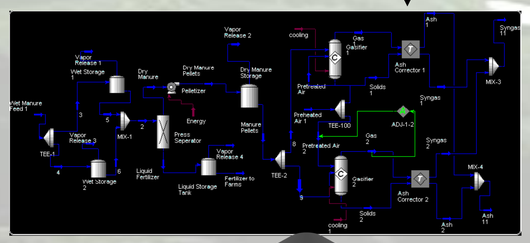


Biomass feed 500 Dry tons of Cow manure per day → **Gasifier Reactor** → **Gas clean-up** → **Fischer-Tropsch** → **Biodiesel**

Cow Manure Composition (wt.%)

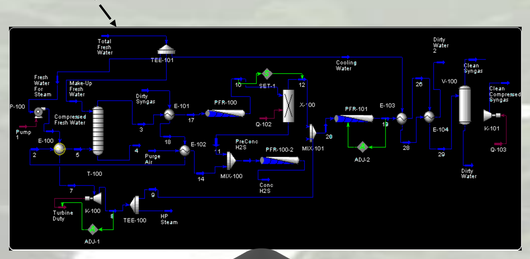


Gasification Process



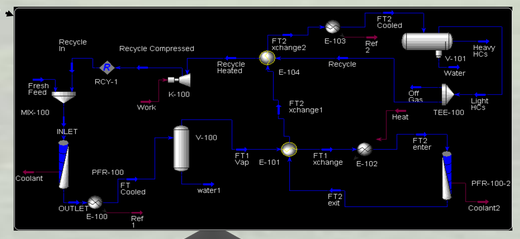
The Gasifier section of this project is the starting block, which converts the biomass into a more usable product. The gas released from this operation is called Syngas which contains a large amount of water, hydrogen, carbon monoxide, carbon dioxide, and nitrogen. There are also some trace components of hydrogen sulfide, ammonia, and ash, which will later be removed. A total of ten gasifiers will be used for this process, each of which is a non-slagging single throat unit. This allows for the ash to be easily separated later as well maintaining better fuel composition ratios.

Gas clean-up



The Gas Clean-Up section of the design is composed of three parts: ash removal, H_2S, and water gas shift. The ash removal section consists of a water scrubber (i.e. a tower in which gas is bubbled up through flowing water). This prevents clogging of later catalytic sites by removing ash particles created from the gasification unit The second area of the cleanup is the reduction of H_2S which, if not removed, will later poison the catalysts. This is done by absorbing Hydrogen Sulfide onto the surface of a sorbent containing Zinc Oxide (ZnO) in a packed bed reactor. The last part of preparation is to adjust the CO to H_2 ratio, which is done by using the water gas shift reaction to pushes the ratio slightly closer to equilibrium, but still far enough away for quick kinetics.

Fischer-Tropsch Reactor



Gas from gas-cleanup enters the FT reactor 1 represented here as a fixed bed reactor. It is then cooled and the components that are dense waxes ($C15_+$) are separated and burned for fuel. The remaining section are fed to a second FT reactor (a reformer) to raise lower carbon numbers to a higher value, at which point it is cooled again and products are run through a three phase separator to separate heavy carbon chains, light carbon chains, and water. The light hydrocarbon components can be recycled to attain higher conversion, heavy carbons chains will be sent on to the Product Purification Distillation train.

Availability of Animal Manure in Wisconsin

Cattle	Animal Units (AU) per County	Manure per AU	Tons Manure per County per Year	Dried Manure per County per Year	Availability per Day Assuming 260 days
Confined Fattened Cattle	5000	10.59	52950	6354	24.4
Confined Milk Cows	5000	15.24	76200	9144	35.2
Other Beef and Dairy Cattle	5000	11.5	57500	6900	26.5
Total	15000	37.33	186650	22398	86.1
Other Sources					
Confined Swine	5000	14.69	73450	8814	33.9
Confined Poultry	5000	10	50000	6000	23.1
Totals	10000	24.69	123450	14814	57

Conclusion: We need to use Cow Manure from 6 counties in South Western Wisconsin

IPRO 347 Team (Spring 2006)

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Conclusion

The IPRO selected cow manure as the biomass feedstock. For the overall process a preliminary design was constructed, with more detailed specifications for the Gasification and Gas clean up processes. Based on this design the initial estimate of the cost of the biodiesel is $25 per gallon.

Recommendations

Future work would include a more detailed FT design, economic analysis and further product utilization.

Economics Analysis

Total Purchase Cost	78,043,378
Bare Module Cost for Equipment/Installation	164,692,757
Direct Permanent Investment	321,150,876
Total Permanent Investment	481,726,315
Working Capital	72,258,947
Total Capital Investment	553,985,262
monthly payment	5,982,045
payment per day	196,670
total sum per day	196,670
Biodiesel production	8,000
Cost per gallon	$ 25