Coal & Biomass Based Transportation Fuel Manufacturing and Sustainability Assessment: A Case Study in Kentucky

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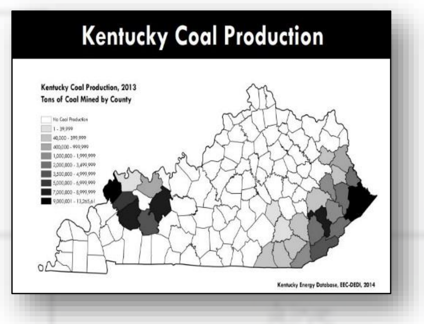
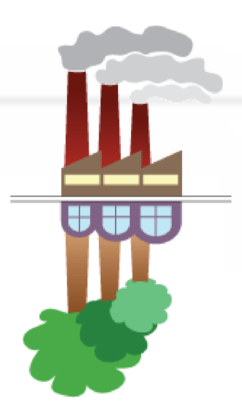
Introduction

- Challenge: Kentucky's biofuel blend rate expected to increase 15% by 2022
- Demand: 775 million gallons of fuel needed per year
- Solution: Generation of transportation fuel from Coal and Biomass Co-Fired Plants
- Supply: Fraction of 80.6 million tons of coal; 2.6 million tons of biomass from agricultural residue



Relation to Sustainable Manufacturing



- Targeting major manufacturing impact areas at macro production level
  - Sustainable design
  - Efficient energy and material use
  - Monitoring airborne emissions
  - Water usage and wastewater
- Alternative solution for meeting consumer demands based on regional resources

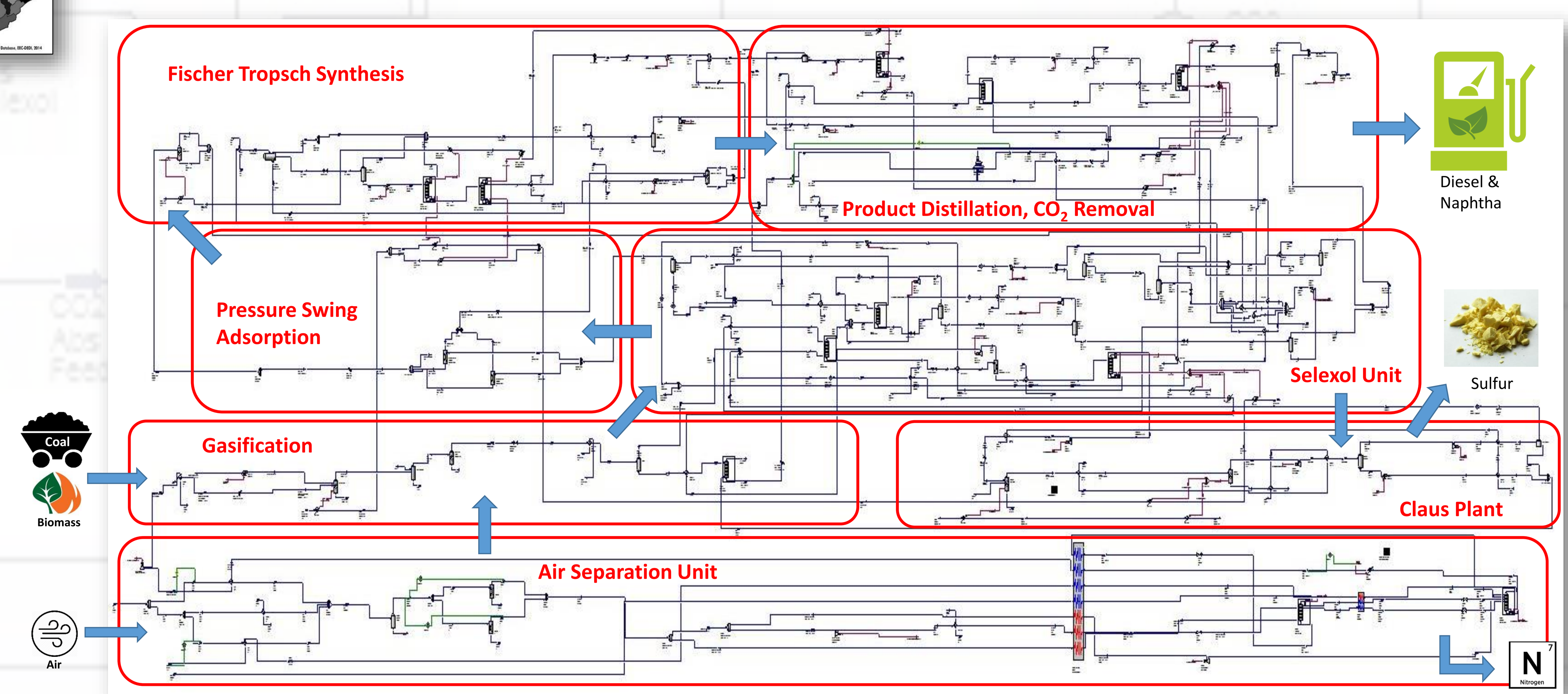
Approach

- Simulate complex process plant via Aspen HYSYS
  - Raw material conversion, mass & energy balances, recycling, fuel production, extraction of valuable side products and CO2 removal
- Conduct sustainability assessment using IChemE Metrics and Inherent Safety Index
  - Economic, environmental and social responsibilities

aspentech IChemE INSTITUTION OF CHEMICAL ENGINEERS

Process Background

- Process description of Coal and Biomass Co-Fired Plants:
  - 85% coal, 15% biomass by weight
  - Air Separation Unit: O_2 production
  - Gasification: Syngas production
  - Selexol Unit: Removal of H_2S & CO_2 from syngas
  - Claus Plant: Conversion of H_2S into elemental Sulfur
  - Pressure Swing Adsorption: Removal H_2 from syngas
  - Fischer Tropsch Synthesis: Hydrocarbon (C_{11}-C_{30}) production
  - Product Distillation: Conversion of C_{11}-C_{30} into diesel & naphtha
  - CO_2 removal: Collection & compression of CO_2



Plant complexity: 167 process units of 11 types

Figure 1: Coal and biomass co-fired transportation fuel manufacturing plant simulated via Aspen HYSYS

Results of Simulation

Table 1: Feedstock Input and Output Ratios

Feedstock input (tons/year)	Coal	6.37E+06
	Biomass	1.14E+06
	Hydrogen	7.74E+03
	Catalyst	1.98E+05
	Water	1.14E+13
Energy input (GW/y)	Electricity	1.77E+03
	Steam	4.61E+07
Product Output (tons/year)	Diesel	1.71E+06
	Naphtha	4.55E+05
	Nitrogen	2.01E+07
	Sulfur	1.38E+05

Table 2: Economic Overview of Plant Operation

Expenditures (MM$/y)	Capital Investment	3,431
	Operating Costs	2,246
	Waste Treatment	1.674
Revenues (MM$/y)	Products Produced	1,493
Net Annual Profit (MM$/y)	$2.41/gal diesel	-3.770
	$4.00/gal diesel	71.957

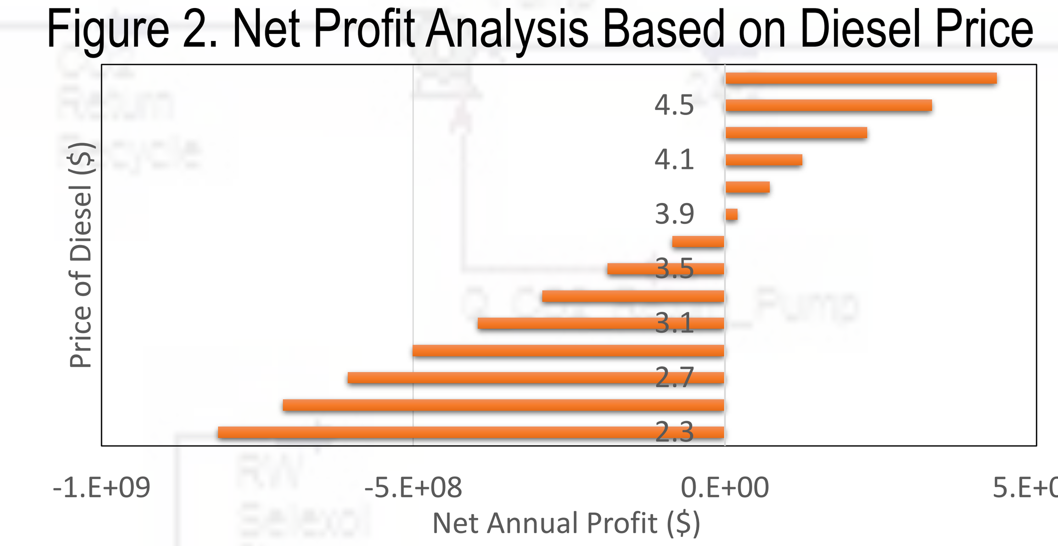
- Expenditures include equipment, utility, labor, maintenance, insurance, administration costs and taxes

Results of Sustainability Assessment

Economic Sustainability:

- Plant operation feasible at diesel prices of approx. $4/gal.

Figure 2. Net Profit Analysis Based on Diesel Price



Environmental Sustainability:

- 8.69E+6 tons/year of CO_2 prohibited from atmosphere via Carbon Sequestration

Social Sustainability:

- 1,680 jobs created
- Safety measures needed as Inherent Safety Index value is too high (39 out of 50)

Process Recommendations

- Recycle cooling water
- Discard Selexol catalyst recovery, decreasing equipment costs
- Add vessel jackets & pressure relief valves, increasing safety
- Consider transportation of goods to determine optimum plant capacity

Conclusions

- Successful simulation of entire plant process
- Comprehensive sustainability assessment conducted
- Improved understanding of the use of this technology
- Future works:
  - Process improvement
  - Strategic planning feasibility study for Kentucky

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