Stump to Pump: Sustainable Fuel Production from Biomass

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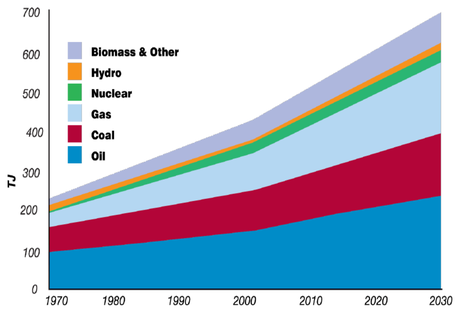
Motivation

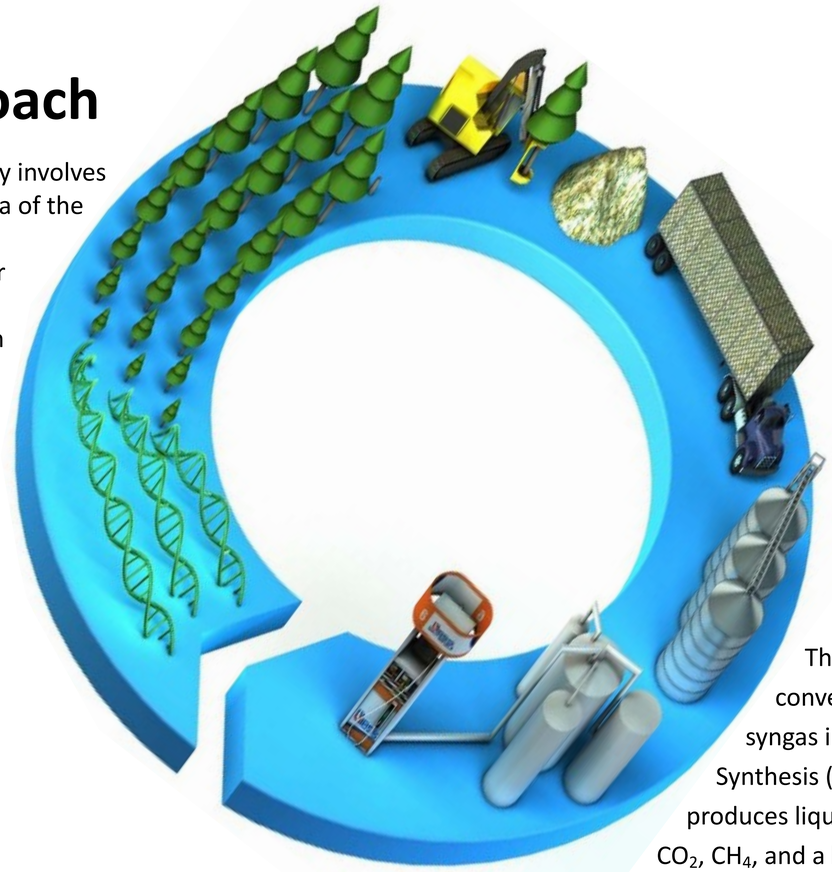
As global energy demands increase, renewable fuels will be needed to supplement, and eventually replace, the diminishing fossil fuel reserves on which we currently depend. Fuels derived from plant materials, or biomass, have been the dominant renewable resource in the past and will continue to play a major role in the future of alternative energy in the United States. The U.S. Energy Independence and Security Act of 2007 requires the blending of 36 billion gallons of biofuels into traditional transportation fuels by 2022. With total annual biomass production projected at over 1 billion dry tons by 2030, the efficient conversion of non-food plant materials into biofuels has the potential to significantly reduce U.S. dependence on fossil fuels.

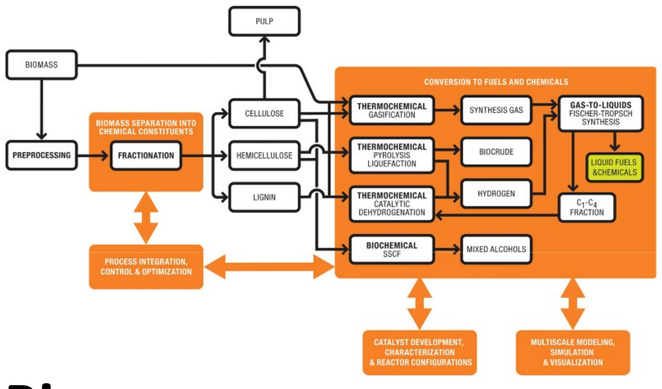
Projected World Energy Demands



The 'Stump to Pump' Approach

From seed to fuel, the conversion of biomass into usable energy involves several interrelated processing steps. With experts in every area of the biofuels production spectrum, Auburn University is uniquely equipped to tackle the issue of sustainable fuel generation. Our 'stump to pump' approach is a collaborative effort among Auburn researchers which seeks to optimize and integrate each step of the biofuels production process.





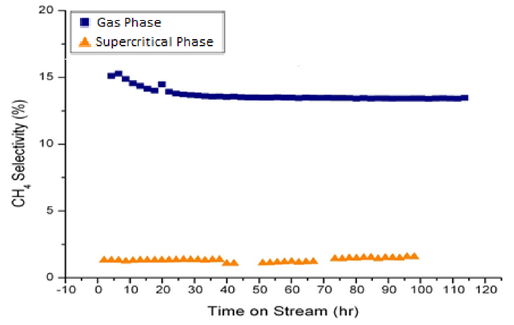
Biomass

Biomass – Any organic material that is carbon-based. Examples include corn, switchgrass, trees, and even animal litter. In the southeastern United States, 65% of the land is forested. Of this abundant natural resource, 75% is privately owned, and can be sold for use in biofuel production. Auburn researchers have been working towards optimizing the harvesting process by increasing the efficiencies of tree harvesting vehicles such as the feller buncher shown below on the left, and the skidder shown below on the right.

Gasification

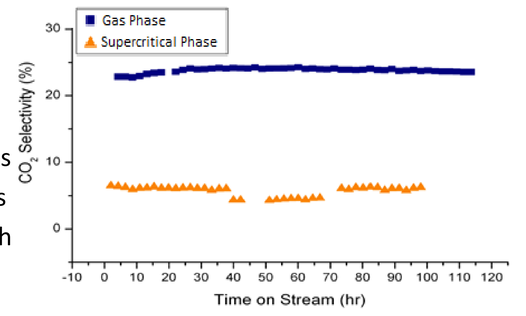
Biomass must first be biologically or thermochemically converted into a chemical intermediate that can then be further converted into a high value product such as gasoline. Gasification is a thermochemical process that converts biomass into syngas (H_2 ,CO and CO_2) without differentiating the sources of carbon. The gasifier shown on the right is being used by Auburn to optimize the production of the syngas that will later be converted into fuels. The simplest of the many reactions that occur in the gasifier are shown below:

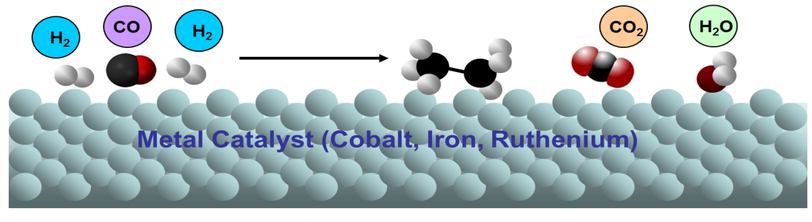
Reaction	Formula
Combustion	$C + \frac{1}{2}O_2 \rightarrow CO$
Combustion	$CO + \frac{1}{2}O_2 \rightarrow CO_2$
Combustion	$H_2 + \frac{1}{2}O_2 \rightarrow H_2O$
Boudouard	$C + CO_2 \rightarrow 2CO$
Water-Gas	$C + H_2O \rightarrow CO + H_2$
Methanation	$C + 2H_2 \rightarrow CH_4$
Steam Methane Re-forming	$CH_4 + H_2O \rightarrow CO + 3H_2$
Water-Gas Shift	$CO + H_2O \rightarrow CO_2 + H_2$



Conversion

The final step in biofuel production is syngas conversion. A promising reaction that converts syngas into high-value products is Fischer-Tropsch Synthesis (FTS). FTS is a set of reactions that produces liquid fuels, but also produces waxes, H_2O, CO_2, CH_4, and a large amount of heat. Auburn researchers are investigating ways to produce less heat, methane, and CO_2 while producing more fuels. One method to improve the reaction is to conduct it in a supercritical fluid medium to remove excess heat and help extract valuable products. Using this method, we have seen upwards of 50% improvement in conversion coupled with a 50% reduction in both CO_2 and CH_4 production. Due to these improvements, catalyst lifetime is extended and fuel is produced more efficiently.





Conclusion

Collaborative research at Auburn University is improving every facet of the biofuels production process, from the growth and handling of plant materials to the design of innovative chemical conversion technologies. Thus, our "stump to pump" approach to biofuels generation has demonstrated great potential for the feasible production of sustainable fuels from biomass.

References

1. Energy demands figure in "Motivation": www.world-nuclear.org
2. "Motivation" facts: Perlack, Robert D., et al. "BIOMASS AS FEEDSTOCK FOR A BIOENERGY AND BIOPRODUCTS INDUSTRY: THE TECHNICAL FEASIBILITY OF A BILLION-TON ANNUAL SUPPLY." 2005, Oak Ridge National Laboratory
3. Equipment images and circular logo: Dr. Steve Taylor, "2012 Energy Solutions" <http://www.sebioenergy.org/2012energysolutions/presentations/Taylor.pdf>