IOWA STATE UNIVERSITY

Center for Sustainable Environmental Technologies

https://www.cset.iastate.edu/tcbiomass2013/

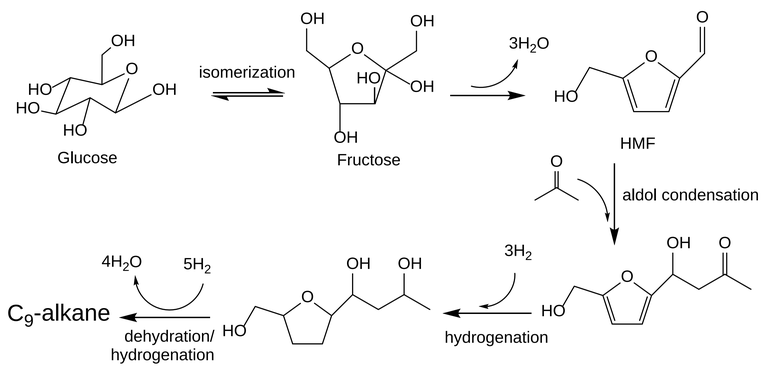
Longwen Ou, Yihua Li, Tristan R. Brown, Guiping Hu, Robert C. Brown

Techno-Economic Analysis of the Production of Hydrocarbons from Pyrolytic Sugars

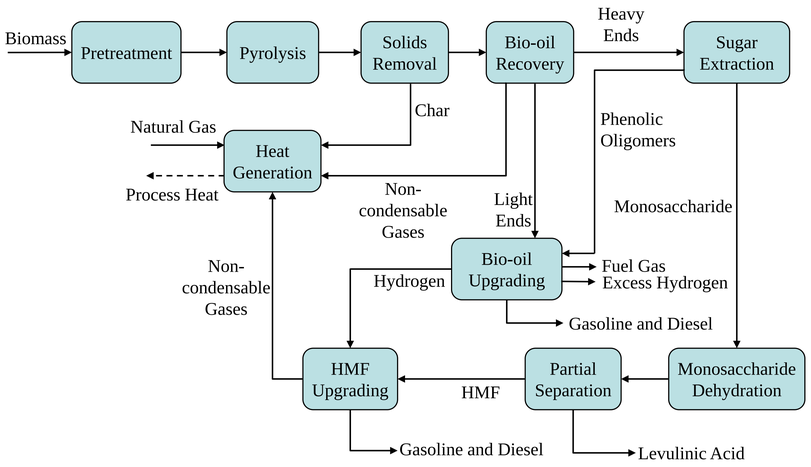
Introduction

- It is possible to produce monosaccharides from biomass fast pyrolysis by recovering bio-oil in several stages according to boiling point.
- The resulting monosaccharides are readily upgraded to liquid alkanes by aqueous-phase processing.
- Alkanes produced by direct aqueous-phase dehydration/hydrogenation of sugars has low value due to high volatility. C-C bonds formation is required to produce gasoline and diesel range fuels from sugars.
- This analysis is performed to understand the economics of fast pyrolysis with monosaccharide extraction and upgrading to liquid fuels as well as to identify possible ways to improve the process economics.

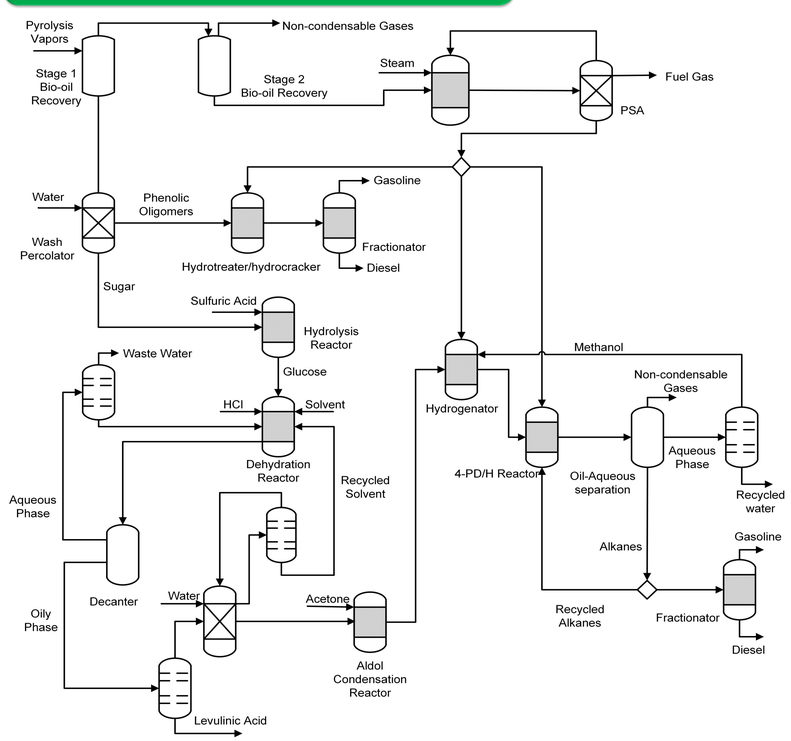
Sugar Upgrading Reaction Pathway



Simplified Process Flow Diagram



Monosaccharide Extraction and Upgrading Process



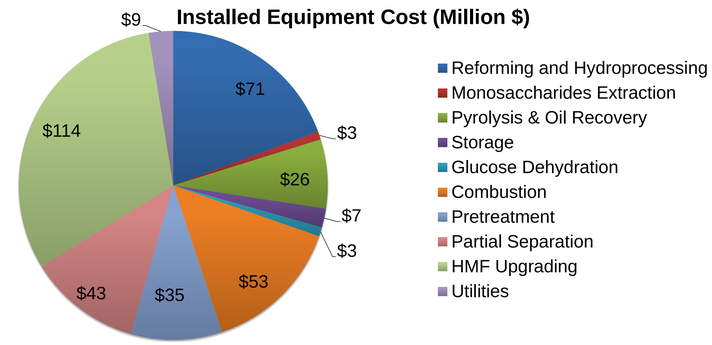
- Bio-oil is recovered in two stages according to boiling point.
  1.“Heavy ends” consisting mostly of water-soluble sugars and water-insoluble phenolic oligomers.
  2.“Light ends” consisting of water, carboxylic acids and aldehydes.
- Heavy ends separated into sugars and phenolic oligomers, the latter of which is hydroprocessed to gasoline and diesel.
- Light ends are steam reformed to produce hydrogen for the process.

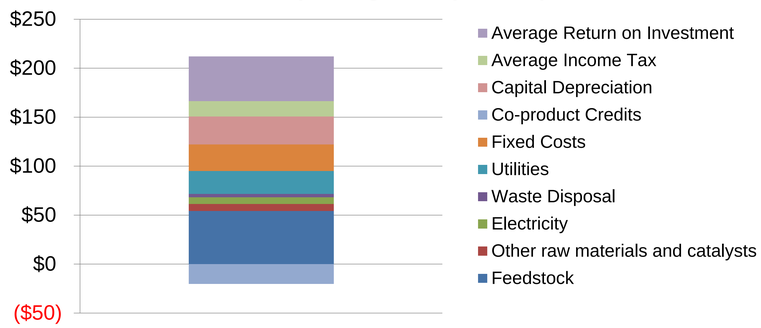
Economic Assumptions and Main Results

Assumptions	
Cost year	$US 2011
Stream factor	90%
Plant Life	30 years
Equity	40%
Loan term	10 years
Equity	40%
Internal rate of return (after tax)	10%
Income tax rate	39%

Results	MM $	% of TPEC			
Total Purchased Equipment Cost (TPEC)	$122	100%	Annual fuel yield	37.2	MM gal/yr
Working Capital	$86	15% of FCI	Yield per feedstock	45.9	gal/dry ton
Total Fixed Capital Investment	$571	469%	Total project Investment	17.8	$/annual gal
Total Investment (with land)	664	546%	MFSP	5.15	$/gal

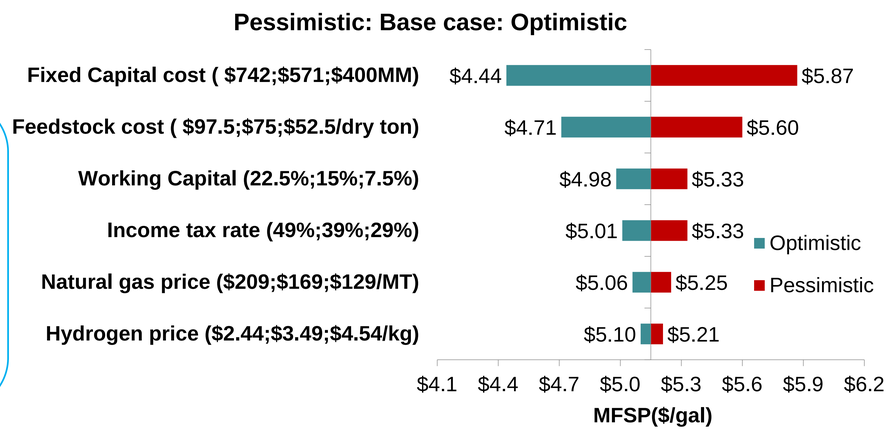
Capital and Operating Costs





- HMF upgrading accounts for 30% of the total capital cost because several large volume, high pressure reactors are used.
- Reforming and hydroprocessing is the second largest contributor to the capital cost, accounting for 19% of the total capital cost.
- Feedstock cost contributes to 27% of the operating cost.
- Utilities cost is high due to the existence of several distillation columns.

Sensitivity Analysis



The authors would like to acknowledge the financial support of the U.S. Department of Energy through the Pacific Northwest National Laboratory.