BIOECONOMY 2017
U.S. Department of Energy

Ethanol Conversion to Fungible Gasoline, Diesel, and Jet Fuel Blend Stocks and High Value Chemical Coproducts (BTEX)

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Vertimass, LLC

July 11-12, 2017
The Pitch for a Prosperous Future

Vertimass Technology

The Problem

Ethanol Producer

Maximum 10% Renewable Ethanol in Gasoline

Ethanol "blend wall"

Vertimass Solution

Vertimass Conversion Process

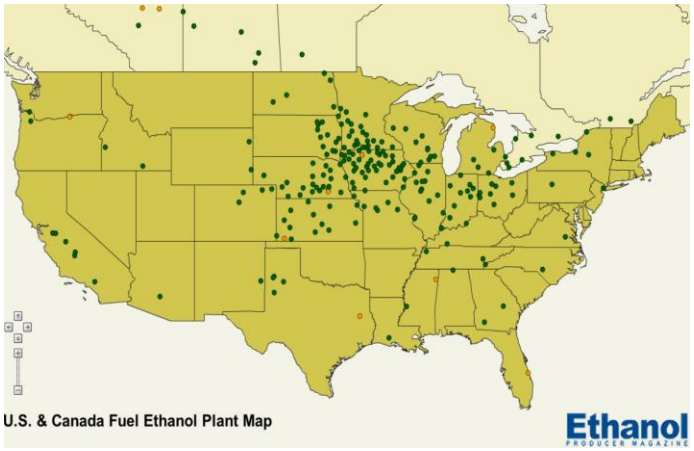
Renewable Chemicals (BTEX)

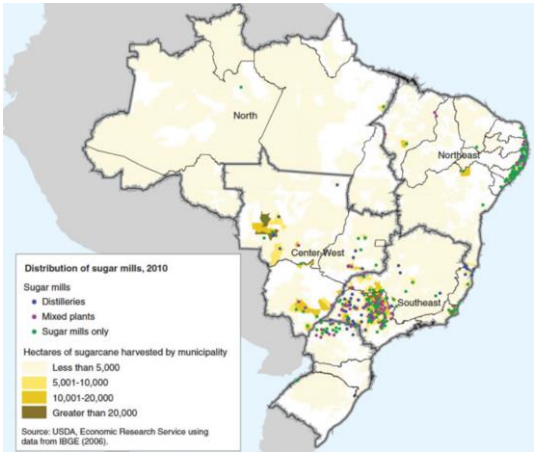
Renewable Jet Fuel

Renewable Gasoline & Diesel Fuels

Market & End Users

Sugar, Starch & Cellulosic Ethanol Producers (U.S., Brazil, Worldwide)[1]





220 Plants in US
(~15 billion gallons/yr)

126 Plants in Brazil
(~6 billion gallons/yr)

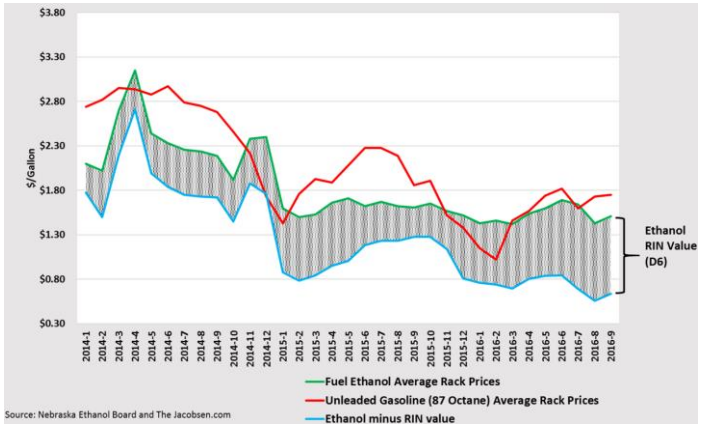
Fuel & Chemical Markets [2,3]

Fuels & Chemicals	Current Billion gal/yr (2016)	Market Size ($Billion)
Gasoline	143.4	215.1
Diesel	58.9	88.3
Jet Fuel	23.7	35.6
BTEX	44.0	110.0
Total	270.0	449.0

1. http://www.energyresourcefulness.org/Fuels/ethanol_fuels/modern_production_of_ethanol.html
2. https://www.eia.gov 3. Assumes Fuel price $1.5/gal, BTX Price $2.5/gal

Benefits & Advantages

- Allows product flexibility for ethanol producers to take advantage of market shifts and maximize profits [1]



- Allows producers to lower plant water and energy usage (overall lower GHG emissions) [2]

Greenhouse Gas Reductions [2]	
Ethanol Feedstock	% GHG reductions
Corn	25%
Sugarcane	61%
Cellulosic	>95%

- Employ existing pipeline network with fungible fuels (rather than transporting via truck & rail with ethanol) [3]

1. http://farmdocdaily.illinois.edu/2015/09/why-isnt-price-ethanol-rins-plummeting.html
2. Renewable Fuels Association (RFA) http://ethanolrfa.org/page/-/rfa-association-site/studies/rfs_ghgs_at_a_glance.pdf?nocdn=1
3. http://www.energyresourcefulness.org/Fuels/ethanol_fuels/modern_production_of_ethanol.html

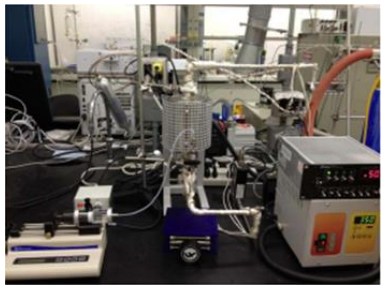
Technology Readiness

TRL3

OAK RIDGE National Laboratory

Lab scale

2012-2014



(0.20 g Catalyst)

150x

TRL4

TechnipFMC

Small Pilot

2016-2017Q2

(30 g Catalyst)

3000x

TRL5

TechnipFMC

Larger Pilot

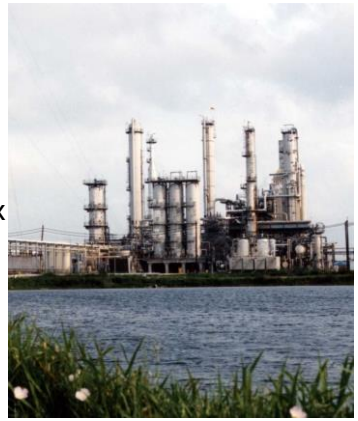
2017Q2-2018

(600 g Catalyst)

68,000,000x

Commercial Operations

2019Q3



(13,700 kg Catalyst)

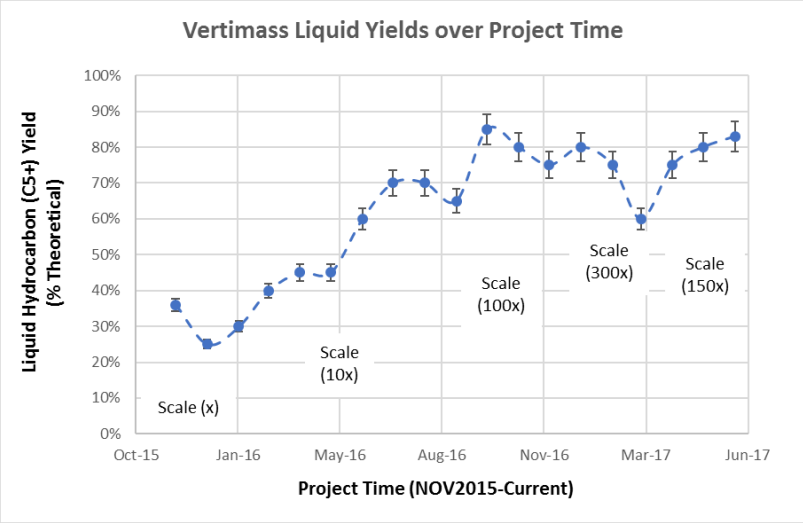
Facility	Scale (x)
Oak Ridge National Lab	x
TechnipFMC small pilot	150 x
TechnipFMC large pilot	3,000 x
Commercial	68,000,000 x

Scale-up from larger pilot to commercial guaranteed

(no valley of death with Demo)

Technical Accomplishments

- **Technology:** successfully transferred from ORNL to TechnipFMC
- **Stoichiometric conversion:** confirmed 100% conversion of ethanol to HCs and water from ORNL to TechnipFMC
- **High Yields:** Increased liquid hydrocarbon yields (C5+) from 36% (initial validation) up to ~80% in 15 months
- **Scale-up:** 150x scale-up in this time frame (ready for next scale)
- **No external hydrogen**
- **Mild Conditions:** Low temperature (350 ºC) and pressure operations (60 psi) operations.
- **Wet ethanol feedstock:** 5-100% ethanol concentrations on V-ZSM-5 & Ga-ZSM-5 have minimal effect.



Low CapEx & OpEx

- Capital Costs have historically been a significant challenge for new biofuel plants
- Vertimass Bolt-on Costs ~12% CapEx for new starch plant, ~4% CapEx for new Cellulosic Ethanol Plant

	Starch Plant[1]	Cellulosic Plant[2]	Vertimass Bolt-On
Ethanol (MMGPY)	61.0	61.0	61.0
CapEx ($MM)	139.3	422.5	**17.0**
CapEx ($/gal)	2.28	6.93	**0.28**

- Operating Costs ~$0.06/gal Ethanol (added to ethanol production cost) mainly for catalyst

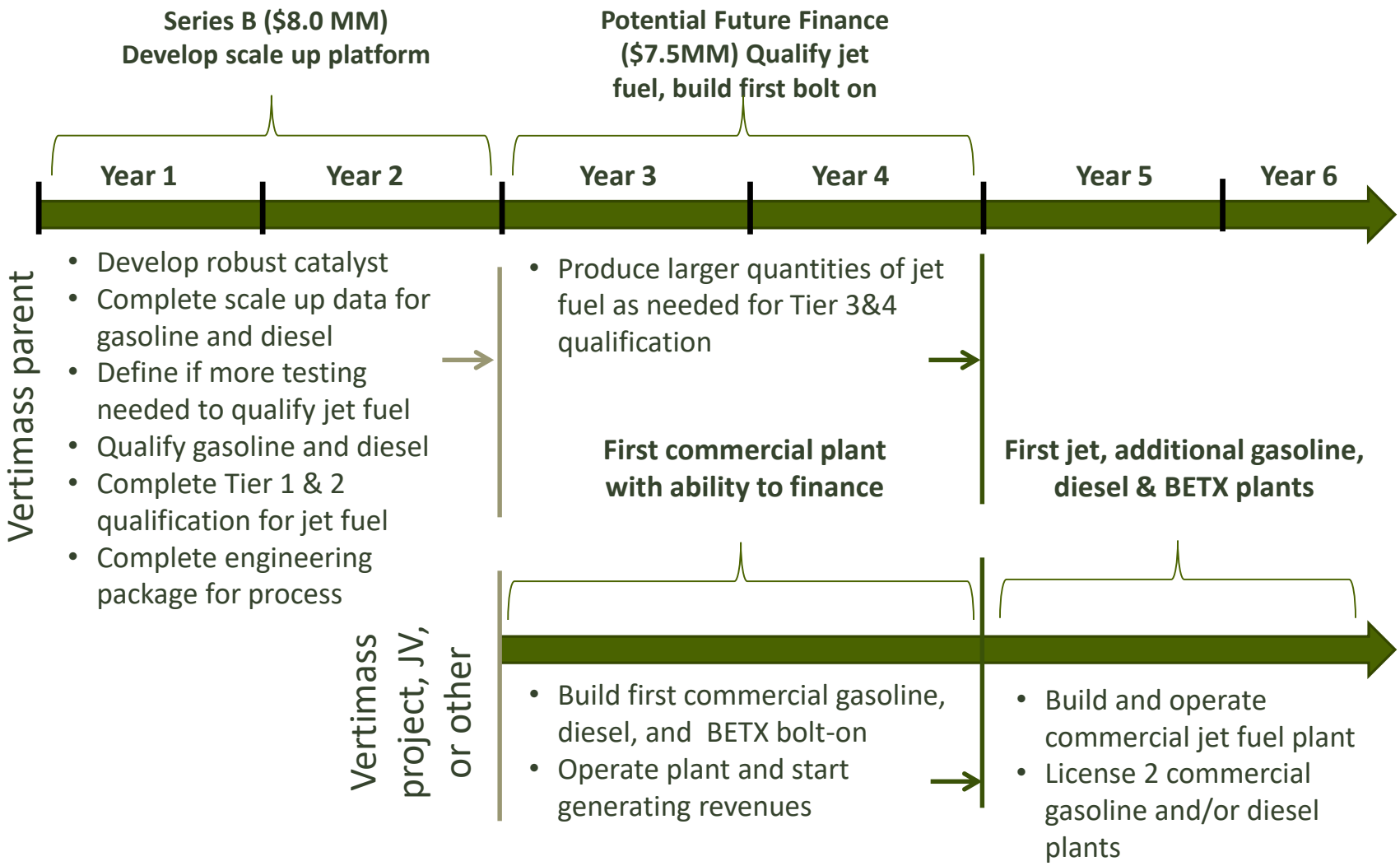
1. NREL TP 28893 using ratio 27.9/136.1 CapEx difference starch/cellulosic with 0.7 exponent (conservative) multiplied by NREL TP 47764 updated CapEx (no inflation applied)
2. Vertimass Bolt-on CapEx $0.20/gallon annual output

Challenges to Overcome

Vertimass™ Transformative fungible biofuels.

- Maximizing liquid hydrocarbon yields portion of product (reaching up to 80%+ now but targeting 90%+)
- Transferring to commercial form of catalyst (working with commercial catalyst producer)
- Securing “first adopter” ethanol plant (currently have verbal agreement)
- Finalizing bolt-on integration with ethanol plant engineering design company (currently in process)
- Qualifying our fuel products (looks very promising)

Future Schedule



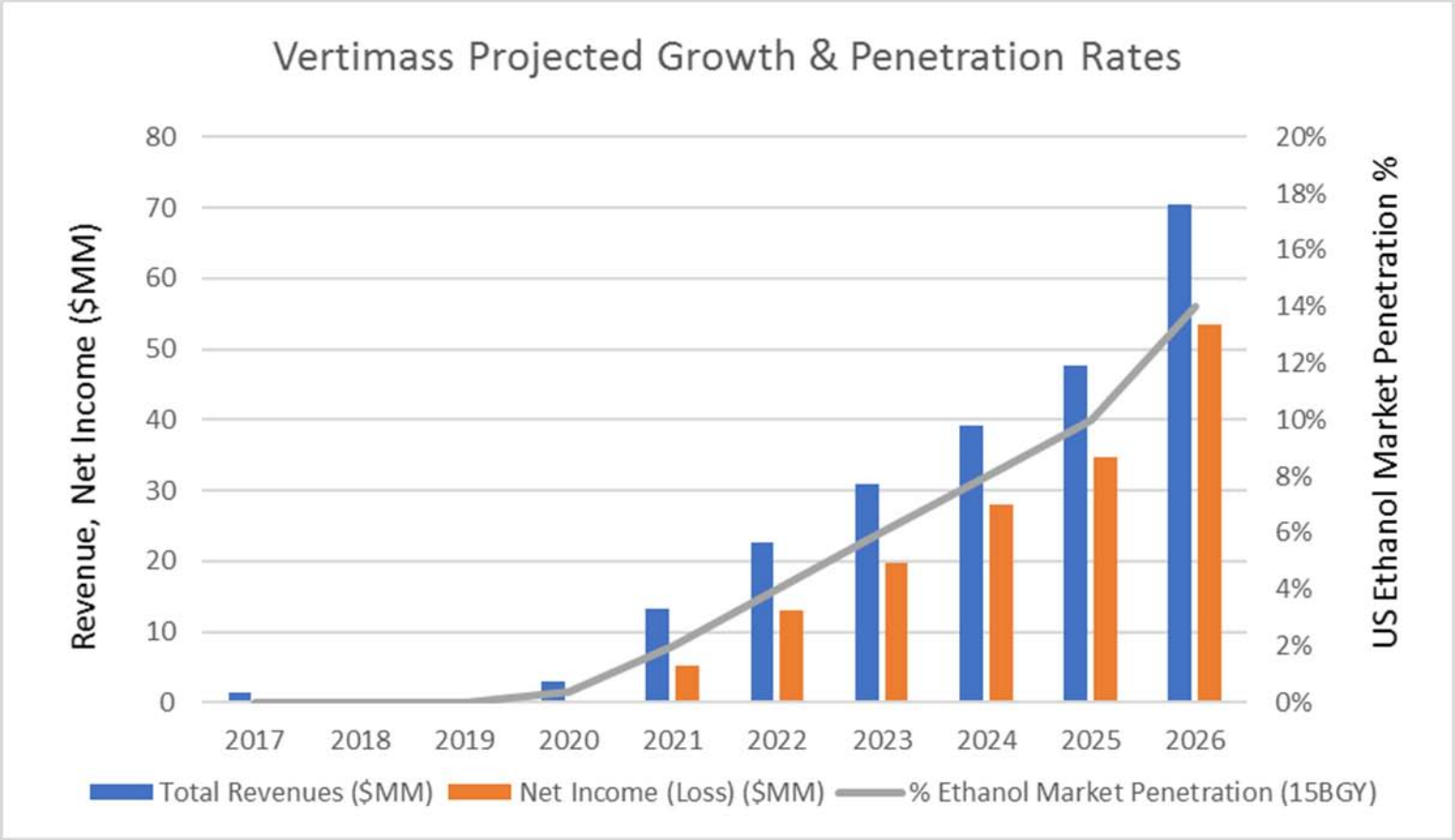
Investment Type Desired

- Series A Completed 2016 ($2.5MM founders, $2.0 DOE award)
- Raising Series B funds ($8.0MM) for engineering design, fuel qualification, continued optimization

Feature	Structure
Total Offering	$8MM, 25% Ownership
Minimum Investment	$100,000, 0.3125% Ownership
Distribution of Profits to Investors *(Investors receive pref. and profits before founders receive any returns)*	1st- 8% Preferred Return, Cumulative 2nd- 100% of Invested Capital 3rd- Pro-Rata Profit Sharing
Return of Capital + Pref. Ret.	6 Years - Estimated
Total Projected Return	Equity Multiple 20X over 8 years
Internal Rate of Return	55% IRR over 8 years
Valuation Potential	$1 Billion, based on 2% US Market Penetration

Why Invest ?

- 20x Multiple over 8 year time frame
- Bolt-on Adoption Rate drives returns



Opportunity

- Green catalyst could revolutionize liquid fuels industry
- Worldwide exclusive license from Oak Ridge National Laboratory
- Protected by 5 ORNL patents with 4 more Vertimass patent applications
- Competitive advantages for up to 200 billion gallon market
- Engaging large fuel and coproduct producers and consumers
- Pilot operations at TechnipFMC to build engineering design basis and qualify blend stocks, BTEX
- Series B investment highlights:
  - 25% Interest in Vertimass
  - 100% capital return + 8% preferred return by year 6 projected
  - 20X multiple; 55% IRR projected over 8 years

Additional Slides

Patents & Presentations

- Patents (applications) through this work

1) US20160362612A1: “Systems and methods for reducing energy consumption in production of ethanol fuel by conversion to hydrocarbon fuels”

2) US 20160362612 A1: “Systems and methods for reducing water consumption in production of ethanol fuel by conversion to hydrocarbon fuels”

3) 62/315889: “Systems and methods for improving yields of high molecular weight hydrocarbons from alcohols”

4) 62/255022: “Systems and methods for improving yields of hydrocarbon fuels from alcohols

- Presentations (samples)

1) "Revolutionary Ethanol Conversion through “Green” Catalyst Technology" Venture West Summit, Feb 28 - March 1, 2017

2) “Novel Vertimass Catalyst for Conversion of Ethanol into Renewable Jet Fuel and High Value Co-Products” Lux Executive Summit Americas, May 9-11 2016

3) “Single Step Ethanol Conversion to BTEX and Jet, Diesel, and Gasoline Blending Components” International Fuel Ethanol Workshop & Expo 2016

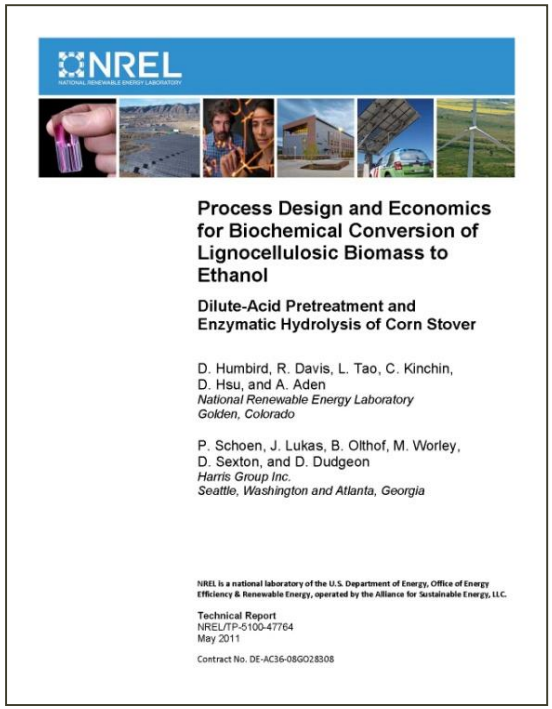
Vertimass Licensed Patents from UT-Battelle

Patent #	Patent Name	Issued Patent # / Application #
1	Zeolite-based SCR catalysts and their use in diesel engine emission treatment	US 8987161 B2
2	Hydrothermally stable, low temperature NOx reduction NH3-SCR catalyst	US 8987162 B2
3	Zeolitic catalytic conversion of alcohols to hydrocarbons	US 9533921 B2
4	Catalytic conversion of alcohols having at least 3 carbon atoms to hydrocarbon blendstock	US 9181493 B2
5	Catalytic conversion of alcohols to hydrocarbons with low benzene content	US 9434658 B2, US 9278892 B2

TechnoEconomic Base Model

- Economics based on NREL research for biomass to ethanol steps (2011 Biochemical Design Report Update), ORNL research for ethanol to hydrocarbon step
- Assumes n^{th}-plant project cost factors and financing (ignores first-of-a-kind risks)
- Discounted cash-flow ROR calculation includes 10% IRR, interest, and income taxes
- Determines the plant-gate or minimum product selling price
- Baseline ethanol selling price is $2.15/gal ethanol (2007$) or $3.27/gal gasoline eq.
- Modeled conversions are based on anticipated pilot-scale performance in 2015

2011 Design Report Update


NREL

Process Design and Economics for Biochemical Conversion of Lignocellulosic Biomass to Ethanol

Dilute-Acid Pretreatment and Enzymatic Hydrolysis of Corn Stover

D. Humbird, R. Davis, L. Tao, C. Kinchin, D. Hsu, and A. Aden
National Renewable Energy Laboratory
Golden, Colorado

P. Schoen, J. Lukas, B. Olthof, M. Worley, D. Sexton, and D. Dudgeon
Harris Group Inc.
Seattle, Washington and Atlanta, Georgia

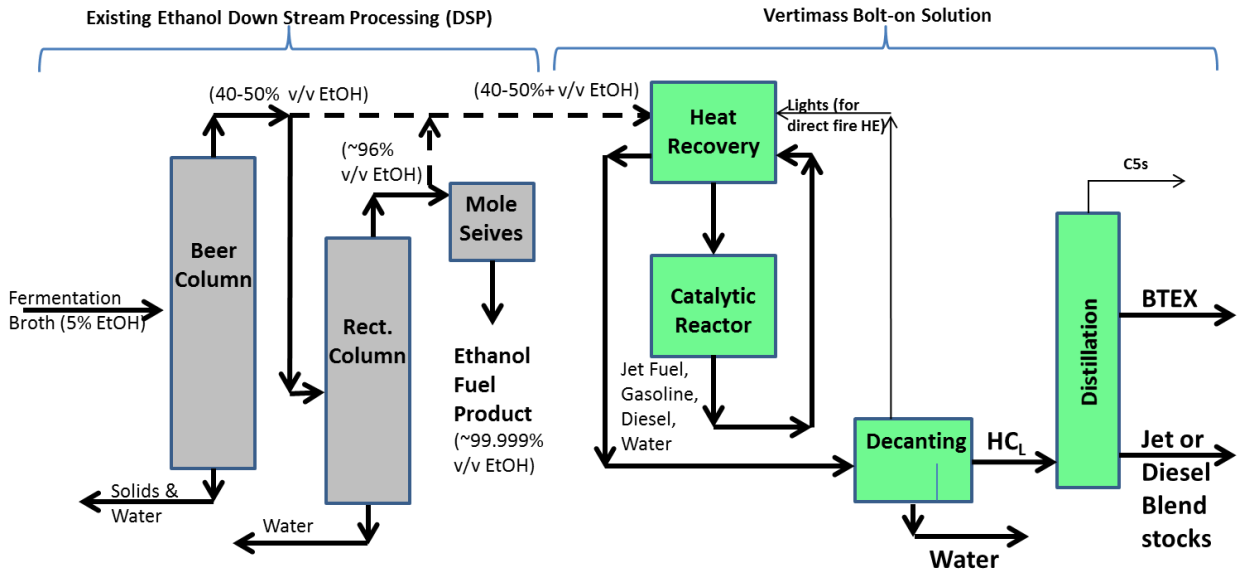
NREL is a national laboratory of the U.S. Department of Energy, Office of Energy Efficiency & Renewable Energy, operated by the Alliance for Sustainable Energy, LLC.

Technical Report
NREL/TP-5100-47764
May 2011

Contract No. DE-AC36-08GO28308

http://www.nrel.gov/docs/fy11osti/47764.pdf

TechnoEconomic Vertimass Model



- Excel based model
- Assumes product taken of rectification column to feed Vertimass bolt-on
- Includes heat integration of Vertifuel products into ethanol facility
- Capital costs for Vertimass bolt-on estimated
- Operating Costs (added to ethanol production costs) include catalyst costs, energy usage, insurance, taxes, maintenance, and labor.