Alcohol to Jet - Isobutanol

Glenn Johnston
Vice President Regulatory Affairs
Gevo Inc.

Session 3 – Next in the Production Line: What to Expect for Future Development and Production of Aviation Alternative Fuels

gevo®

Biocatalyst (yeast)

Gevo integrated fermentation technology (*GIFT*®)

Isobutanol

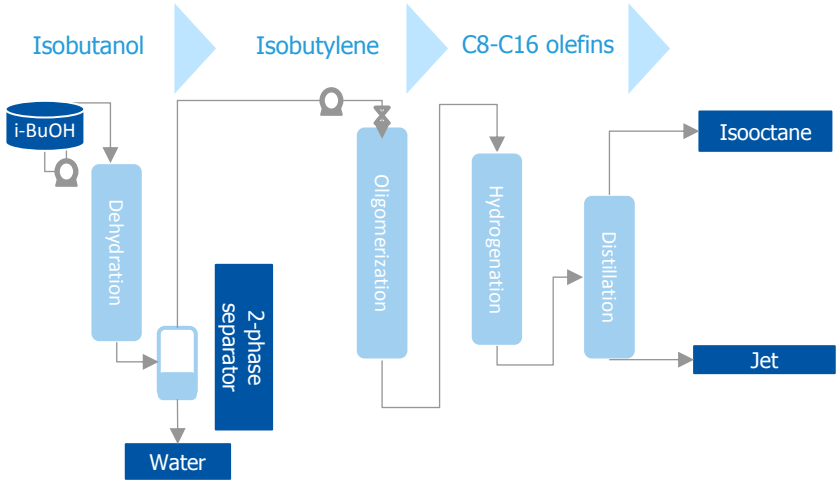
Alcohol to Jet (ATJ)

Alcohol to Hydrocarbons

- Sugar to Isobutanol fermentation facility owned by Gevo and producing renewable isobutanol.
- Location – Luverne, MN
- Creating the feedstock for our demonstration scale ATJ process in Silsbee, Texas

- Proprietary processing based on standard unit operations in a typical petroleum refinery.
- Gevo has been producing jet fuel since 2011 with over 5 years of process performance data on process capability and feedstock, including QA/QC process control charts to 6 SIGMA.
- Process yields have been shown at 98% of theoretical.

Process Flow



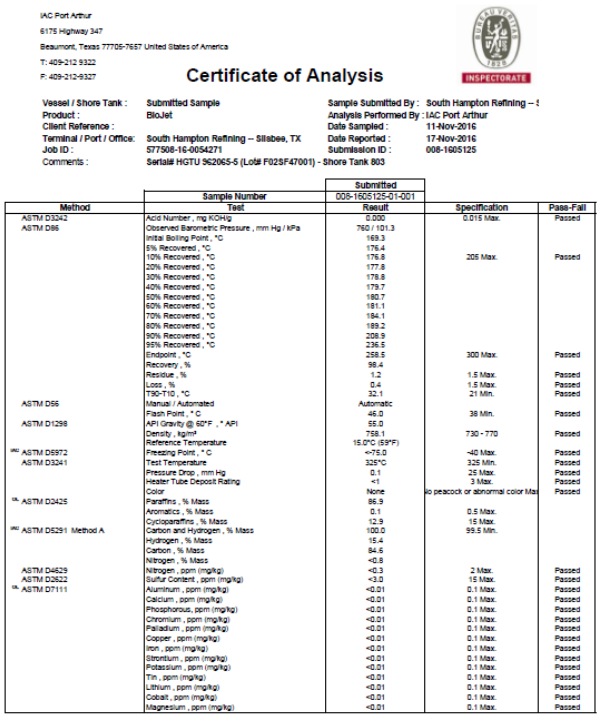
ASTM D7566 Annex 5

Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons

A5. ALCOHOL-TO-JET SYNTHETIC PARAFFINIC KEROSENE (ATJ-SPK)

Property (Test Method)	ASTM D1655 Specification (Jet A/Jet A-1)	Typical Jet A-1 (CRC 647)	ATJ-SPK
Freezing Point (ASTM D2386)	-40°C max Jet A -47°C max Jet A-1	- 50°C	**<-80°C**
Flash Point (ASTM D3828)	38°C min	48°C	**48°C**
Energy Density (Net Heat of Combustion) (ASTM D3338)	42.8 MJ/kg min	42.9 MJ/kg	**43.2 MJ/kg**
Thermal Oxidation Stability (JFTOT) (ASTM D3241)	pass	pass	**pass**
Total Sulfur Content (ASTM D2622)	0.3% max	0.05%	**<0.01%**

- Extensive Quality Control Process of each lot which includes requirements from ASTM, Joint Inspection Group (JIG), DEFSTAN 91-91 and others.
- Analytical testing completed by Third Party per ASTM D7566 Annex 5 requirements.
- Chain of custody requirements on container cleaning procedures, transfer documents, etc. built in to Gevo standard SOPs.



IAC Port Arthur
6175 Highway 347
Beaumont, Texas 77705-7657 United States of America
T: 409-212 9322
F: 409-212-9327

Certificate of Analysis

INSPECTORATE

Vessel / Shore Tank :	Submitted Sample	Sample Submitted By :	South Hampton Refining – S
Product :	BioJet	Analysis Performed By :	IAC Port Arthur
Client Reference :		Date Sampled :	11-Nov-2016
Terminal / Port / Office:	South Hampton Refining – Silsbee, TX	Date Reported :	17-Nov-2016
Job ID :	S77508-16-0054271	Submission ID :	008-1605125
Comments :	Serial# HGTU 9G2065-5 (Lot# F02SF47001) - Shore Tank 803		

		Submitted		
	Sample Number	008-1605125-01-001		
Method	Test	Result	Specification	Pass-Fail
ASTM D3242	Acid Number , mg KOH/g	0.000	0.015 Max.	Passed
ASTM D86	Observed Barometric Pressure , mm Hg / kPa	760 / 101.3		
	Initial Boiling Point , °C	169.3		
	5% Recovered , °C	176.4		
	10% Recovered , °C	176.8	205 Max.	Passed
	20% Recovered , °C	177.6		
	30% Recovered , °C	178.8		
	40% Recovered , °C	179.7		
	50% Recovered , °C	180.7		
	60% Recovered , °C	181.1		
	70% Recovered , °C	184.1		
	80% Recovered , °C	189.2		
	90% Recovered , °C	208.9		
	95% Recovered , °C	236.5		
	Endpoint , °C	258.5	300 Max.	Passed
	Recovery , %	98.4		
	Residue , %	1.2	1.5 Max.	Passed
	Loss , %	0.4	1.5 Max.	Passed
	T90-T10 , °C	32.1	21 Min.	Passed
ASTM D56	Manual / Automated	Automatic		
	Flash Point , ° C	46.0	38 Min.	Passed
ASTM D1298	API Gravity @ 60°F , ° API	55.0		
	Density , kg/m³	758.1	730 - 770	Passed
	Reference Temperature	15.0°C (59°F)		
IAC ASTM D5972	Freezing Point , ° C	<-75.0	-40 Max.	Passed
ASTM D3241	Test Temperature	325°C	325 Min.	Passed
	Pressure Drop , mm Hg	0.1	25 Max.	Passed
	Heater Tube Deposit Rating	<1	3 Max.	Passed
	Color	None	No peacock or abnormal color Mat	Passed
LAL ASTM D3425	Paraffins , % Mass	86.9		
	Aromatics , % Mass	0.1	0.5 Max.	
	Cycloparaffins , % Mass	12.9	15 Max.	
IAC ASTM D5291 Method A	Carbon and Hydrogen , % Mass	100.0	99.5 Min.	
	Hydrogen , % Mass	15.4		
	Carbon , % Mass	84.6		
	Nitrogen , % Mass	<0.5		
ASTM D4629	Nitrogen , ppm (mg/kg)	<0.3	2 Max.	Passed
ASTM D2622	Sulfur Content , ppm (mg/kg)	<3.0	15 Max.	Passed
LAL ASTM D7111	Aluminum , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Calcium , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Phosphorous , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Chromium , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Palladium , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Copper , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Iron , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Strontium , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Potassium , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Tin , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Lithium , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Cobalt , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Magnesium , ppm (mg/kg)	<0.01	0.1 Max.	Passed

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Certificate of Analysis

INSPECTORATE

Vessel / Shore Tank :	Submitted Sample	Sample Submitted By :	South Hampton Refining – S
Product :	BioJet	Analysis Performed By :	IAC Port Arthur
Client Reference :		Date Sampled :	15-Sep-2016
Terminal / Port / Office:	South Hampton Refining – Silsbee, TX	Date Reported :	04-Oct-2016
Job ID :	S77508-16-0041472	Submission ID :	008-1603881
Comments :	Serial# HGTU 9G2065-5 (Lot# F02SF47001) - Shore Tank 803		

		Submitted		
	Sample Number	008-1603881-01-006		
Method	Test	Result	Specification	Pass-Fail
LAL ASTM D7111	Platinum , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Manganese , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Molybdenum , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Sodium , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Nickel , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Lead , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Titanium , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Vanadium , ppm (mg/kg)	<0.01	0.1 Max.	Passed
	Zinc , ppm (mg/kg)	<0.01	0.1 Max.	Passed
IAC ASTM D7359	Fluorine , ppm (mg/kg)	<1.0	1 Max.	Passed
	Chlorine , ppm (mg/kg)	<1.0	1 Max.	Passed
ASTM D6304 Proc. B	Water Content , ppm (mg/kg)	36	75 Max.	Passed

IAC Analysis performed by alternative IAC laboratory.
LAL Analysis performed by External Laboratory
Note Product meets specification per ASTM D7566-16b Annex 5

For Inspectorate:
Narendhar Arumandla, Quality Manager

ISO 9001 registered; BSI certificate # FS 666662 Page 2 of 2

- True carbon reduction comes from using renewable carbon and not emitting petroleum carbon back into the atmosphere
- Through ASTM D6866 carbon 14 analysis we show our customers that our product is 100% renewable carbon and does not contain petroleum derived carbon.

BETA

Biobased and Biogenic Carbon Testing Laboratory
ISO/IEC 17025:2005 Accredited

Beta Analytic, Inc.
4985 SW 74 Court
Miami, FL 33155 USA
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com
www.betalabservices.com

Summary of Results - % Biogenic Carbon Content: ASTM D6866-16 Method B(AMS)

Submitter	Ms. Maureen Sullivan
Company	Gevo
Date Received	December 02, 2016
Date Reported	December 09, 2016

Percent Biogenic Carbon 100 %

Laboratory Number	Beta-452315
Testing Method	D6866-16 Method B(AMS)
Percent modern carbon (pMC)	103.4 +/- 0.3 pMC
Atmospheric adjustment factor	101.5; =pMC/1.015

Package received - labeling COC

View of content (1mm x 1mm scale)

Representative sample analyzed (1mm x 1mm scale)

Required Disclosures:

1. All work was done at Beta Analytic in its own chemistry lab and AMS. No sub-contractors were used.
2. Beta's chemistry laboratory and AMS do not react or measure artificial C14 used in biomedical and environmental AMS studies. Beta is a C14 tracer-free facility.
3. Validating quality assurance is verified with a Quality Assurance report posted separately to the web library containing the PDF downloadable copy of this report.

* ASTM D6866-16 quotes precision on Percent Biogenic Carbon as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy of the % biogenic carbon result relies on the carbon present in the analyzed material having been in recent equilibrium with CO2 in the air and/or fossil carbon (from living systems more than 40,000 years old). "Percent biogenic carbon" specifically relates % renewable (i.e. non-fossil) organic carbon to total carbon (TC), not to total mass. Percent biogenic carbon is calculated by dividing pMC by the applicable REF adjustment factor specified in ASTM-D6866-16. % biogenic carbon = (pMC / REF] +/- 3 % absolute).

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Miami, FL 33155 USA
Tel: 305-667-5167
Fax: 305-663-0964
info@betalabservices.com
www.betalabservices.com

Analytical Measure - % Biogenic Carbon Content: ASTM D6866-16 Method B(AMS)

Submitter Gevo

Laboratory Number	Beta-452315
Biogenic Material	Biobased Material
Date Received	December 02, 2016
Date Reported	December 09, 2016

Percent Biogenic Carbon 100 % *

Proportions Biogenic Carbon vs. Fossil-Based Carbon Indicated by 14C content

* ASTM D6866-16 quotes precision on Percent Biogenic Carbon as +/- 3% (absolute). The cited precision on the analytical measure (pMC) is 1 sigma (1 relative standard deviation). The reported result only applies to the analyzed material. The accuracy o the % biogenic carbon result relies on the carbon present in the analyzed material having been in recent equilibrium with CO 2 in th air and/or fossil carbon (from living systems more than 40,000 years old). "Percent biogenic carbon" specifically relates renewable (i.e. non-fossil) organic carbon to total carbon (TC), not to total mass. Percent biogenic carbon is calculated by dividin pMC by the applicable REF adjustment factor specified in ASTM-D6866-16. % biogenic carbon = (pMC / REF] +/- 3 % absolute).

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NARA
Northwest Advanced Renewables Alliance

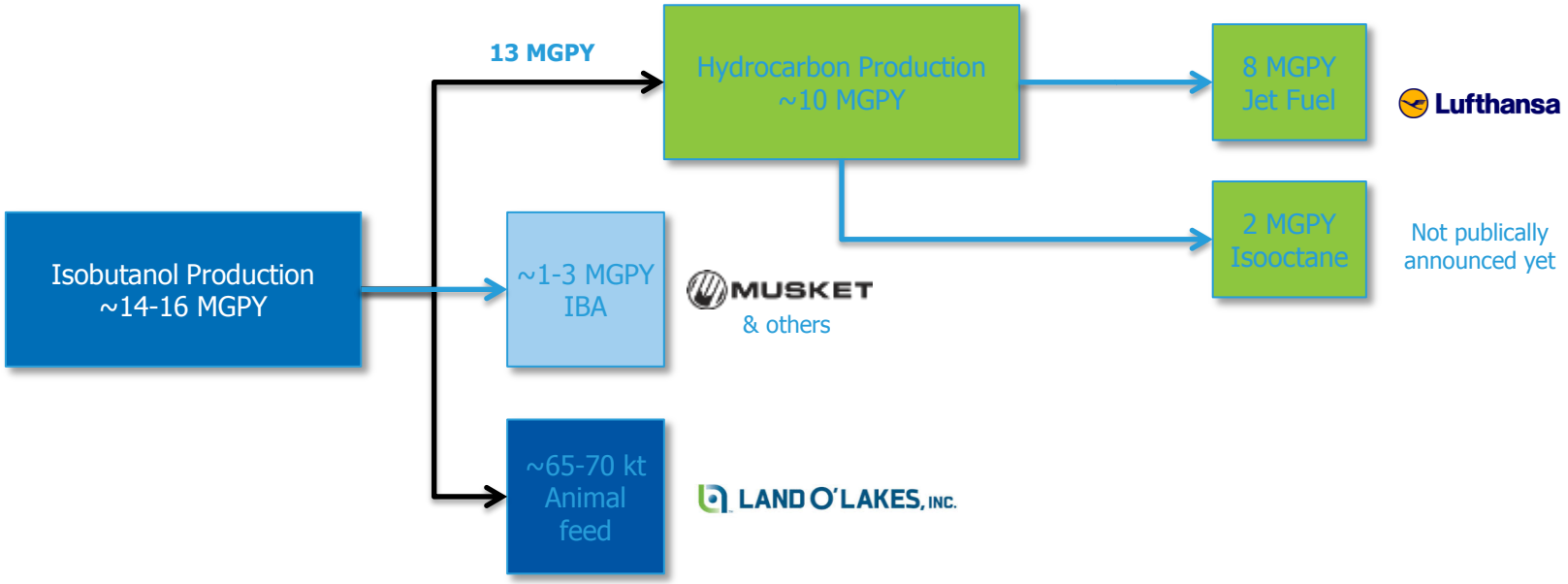
SUPPLY CHAIN

USDA NIFA
United States Department of Agriculture
National Institute of Food and Agriculture

First History Commercial Flight with 20% Blend ATJ Cellulosic Renewable Jet Fuel

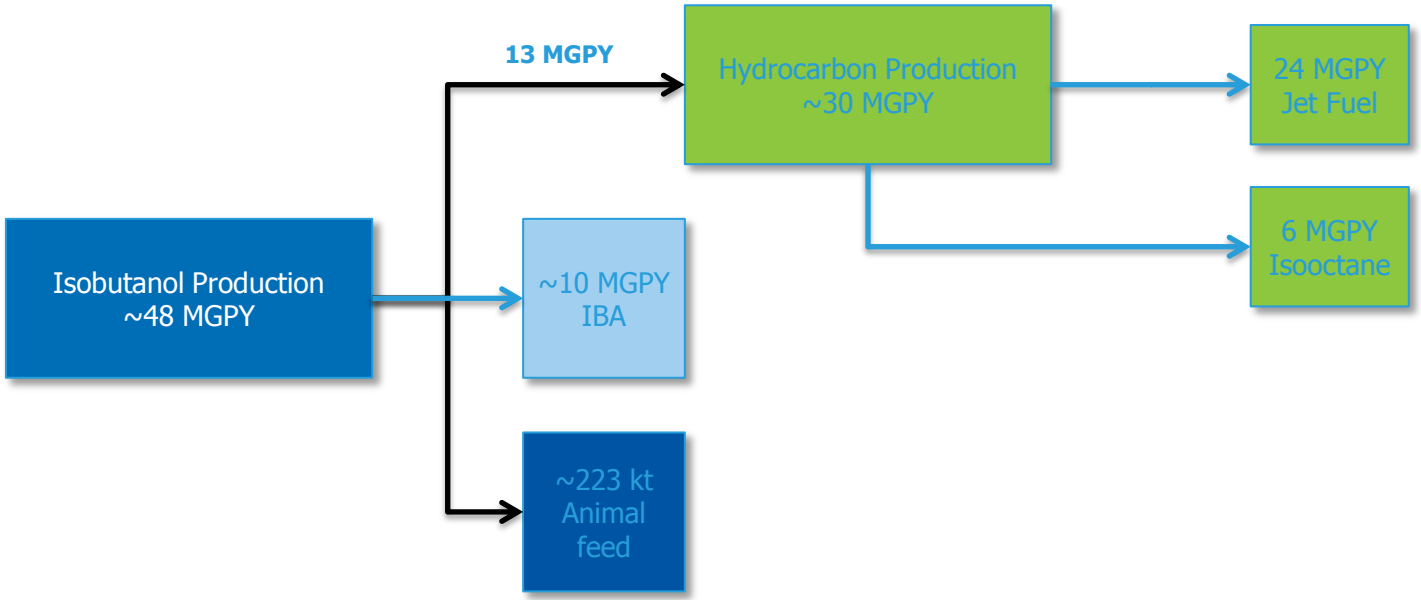
- Strategy: Leverage installed assets at Luverne and adding the capability to produce 7-10 MGPY of hydrocarbons. Luverne is a proving ground for products and supply chain development.

Potential Buildout Overview



- Those participating at Luverne will be advantaged for future volumes from future expansion

Commercial Buildout Overview (Beyond Luverne)



- *If you had the chance to make 3 policy requests to States to facilitate the development and deployment of alternative fuels, what would they be?*

1-Stability

2-Simple

3-Support

ICAO

THANK YOU