* *Globally by Biofuels Digest, USA*

LEED CERTIFIED PLATINUM GREEN BUILDING

PRAJ – GEVO
for Sustainable Aviation Fuel

Innovate • Integrate • Deliver

February 2020

Facts at a glance - PRAJ

FACTS AT A GLANCE

- Revenue $136 Mn. FY 19
- 750+ References
- Presence Across 75 Countries
- 350 + Overseas References
- 4 Manufacturing Facilities
- 1200+ Employees
- 90+ Research Scientists
- Holds 25+ Patents
- 40%+ Business - Repeat Customers FY19
- 8 **%** of Global ethanol production
- **35** Glorious Years
- **22** Years Strong Track record of Dividend

Business offerings






Bioenergy

Solution Provider in 1G & 2G Bio-Ethanol plants Modernization & upgradation,

Compressed Bio Gas (CBG)

High Purity

High purity applications for pharma, biotech, cosmetics industry

Engineering Businesses

Brewery Plants

Critical process equipment & systems, Modular Process Skids , Special Projects

Effluent Recycling & ZLD

R&D

Future Strategic Development & Collaboration

- Renewable Chemicals
  - Xylitol
  - Furfural
  - Vitamin E

Global Leadership

- Audit and FEED
- Technology & Engineering
- Process Equipment Manufacturing
- Installation and Integration
- Commissioning & Handover
- Life cycle Management
- Project Management

GLOBAL ETHANOL PLANT SOLUTIONS LEADER

- 750+ Global References
- >350 installations overseas
- Installations in 75 countries 5 continents
- 9000+ Samples of 1G feedstock fingerprinted
- End-To-End Service Provider
- ~61 % Share In India (2017-18)
- 100% Share In Colombia
- 50%+ Share in Emerging Markets


Riopaila, Colombia


Vicentin, Argentina


Vivergo Fuels, UK

3 decades of leadership in Bio-Industrial space

2nd Gen. cellulosic ethanol technology

Commissioned of Praj's own and India's first 2nd gen. Bio-refinery (12 MT/day) - now in 3rd year of operation
Working on 4 commercial offerings on track

2017-18..

2014-15

Commercial demo plant engineering

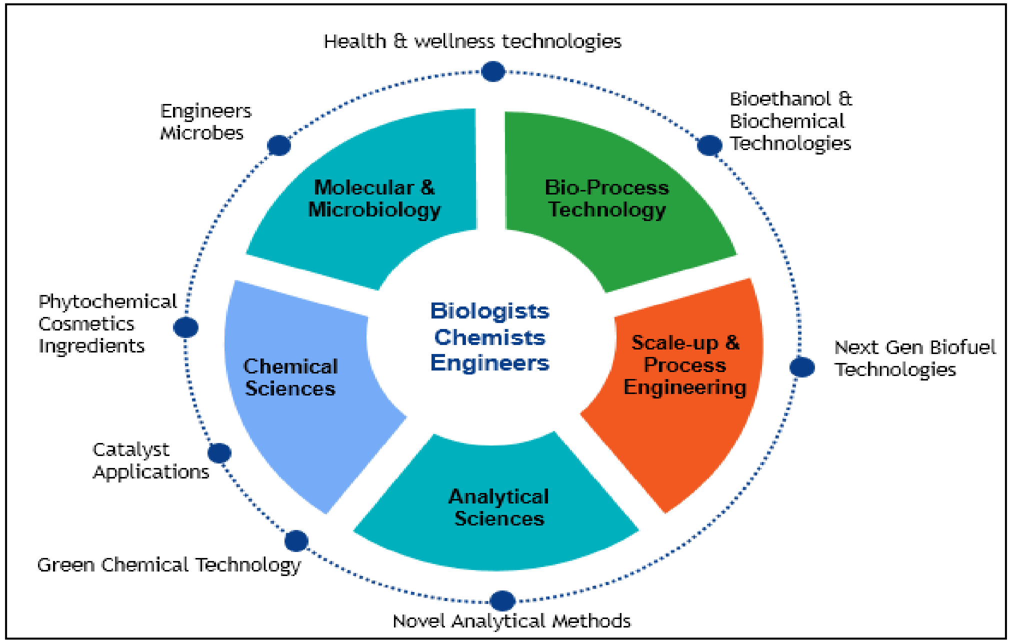
Pilot plant operation

2010-13

2008-10

Pilot Scale & Engineering

Matrix – The R&D Centre



- ❖ In-House R&D facility - Certification by DSIR*, GOI
- ❖ **$ 25-30 Mn** Captive investment
- ▪ First of its kind R&D facility with Bench & Pilot scale facilities that enable **validation** of scientific assumptions as well as rapid **commercialization**
- ❖ **90+** technologists and growing
- ❖ **Ongoing** research on performance improvement & cost efficiency

*Department of Scientific and Industrial Research

About GEVO

OVERVIEW OF GEVO

Business Overview

- Headquarters: Englewood, CO
- Founded: 2005
- Employees: ~50 (20 in Colorado, 30 in Minnesota) + 20 Contractors
- Proprietary technology position (patents and know-how) for the production of isobutanol and hydrocarbon fuels and chemicals
- **Technologies proven to work**
- **Produces: Ethanol, IBA, Jet Fuel, Isooctane, Feed, Corn Oil**

Facility Overview

- Corporate Headquarters (Englewood, CO) – Offices and Labs
- Alcohol Production Facility (Luverne, MN) – 20MGPY Ethanol, 1.5 MGPY IBA. Potential for low carbon credits. Potential to build out IBA to 14-18 MGPY leveraging already install capex
- Jet and Isooctane Biorefinery* (Silsbee, TX) – Demo/specialty commercial facility that transforms isobutanol to jet fuel, isooctane and para-xylene (PX). 100 KGPY of capacity

Luverne, MN Facility

Silsbee, TX Facility

End Markets Served

- Renewable jet fuel
- Renewable gasoline (isooctane)
- Specialty gasoline blendstocks
  - "Ethanol (ETOH) free" high octane gasoline
    - Marine / Off-road blendstock
    - On-road use for high performance, racing and classic cars
  - Low carbon ethanol
- Animal Feed, protein, and corn oil
- Specialty chemicals and solvents

Customers, Partnerships, and Agreements

Lufthansa · Haltermann Carless · U.S. Air Force · U.S. Army · Buc-ee's · praj · Total · Coca-Cola · Gulf · BCD · air bp · FedEx · Alaska Airlines · Kinder Morgan · Virgin Australia · Toray · Delta · SAS

Why Sustainable Aviation Fuel

Demand of Jet fuel (2019): 3 billion gallons per year & growing

Contributing 2% of man made carbon emissions – 859 million tons of CO2 per year

Objective of Aviation Industry:

Carbon Neutral Growth

Sustainable Aviation Fuel (SAF)

Why SAF in India

- Carbon Neutral Growth
- Energy Security
- Import bill
- Alignment with 'Make in India' & 'Swaccha Bharat'

SAF - Properties

- Clean substitute to fossil jet fuels - Low carbon intensity **(~80% GHG savings w.r.t fossil jet fuel**)

- **Drop in fuel** : blended with fossil jet fuel up-to 50%
  - No special infrastructure requirements
  - No modification in aircraft

- **Sustainable feedstock** :
  - Sugary (Syrup, Molasses)
  - Starchy (grains)
  - LC Biomass (Straws, Wood, Stover etc.)
  - Oil crops

SAF: Only energy solution to mitigate CO2 emission growth in aviation sector

Conversion processes & Blending

Sr.No.	Conversion Process	Abbreviation	Possible feed stocks	Blending % Volume
1	Fischer-Tropsch hydroprocessed synthesized paraffinic kerosene	FT- SPK	Coal, natural gas, biomass	50%
2	Synthesized paraffinic kerosene produced from hydroprocessed esters and fatty acids	HEFA- SPK	Vegetable oils and fats, animal fat, recycled oils	50%
3	Synthesized isoparaffins produced from hydroprocessed fermented sugars	HFS-SIP	Biomass used for sugar production	10%
4	Synthesized kerosene with aromatics derived by alkylation of light aromatics from nonpetroleum sources	FT-SPK/A	Coal, natural gas, biomass	50%
5	Alcohol-to-jet synthetic paraffinic kerosene	ATJ-SPK	Biomass used for starch and sugar production and cellulosic biomass for iso-butanol production	50%

SAF - Production Process

Sugary, Starchy & LC Biomass

→

Isobutanol (IBA) Plant

- Fermentation
- IBA Recovery
- Distillation

Isobutanol

$C_4 H_{10} O$

→

Hydrocarbons Plant (ATJ)

- Dehydration
- Oligomerization
- Hydrogenation
- Distillation

→ **SAF (Synthesized Paraffinic Kerosene SPK)**

→ **Iso-Octane**

COMBINED BIOPROCESS AND CHEMICAL PRODUCTION

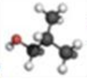
Isobutanol Production – Side-by-Side with Ethanol

Isobutanol

Drop-in Markets - Isobutanol

Specialty Chemicals & Solvents

Specialty Gasoline Blendstock (Marine/Off-Road)



Isobutanol

Hydrocarbon Biorefinery

Hydrocarbons

Drop-in Markets - Hydrocarbons

Jet Fuel

Isooctane (gasoline)

MAKING PRODUCTS

1 Million Liter Fermenter

Ethanol and IBA Production - Luverne, MN

Hydrocarbon Production* Silsbee, TX

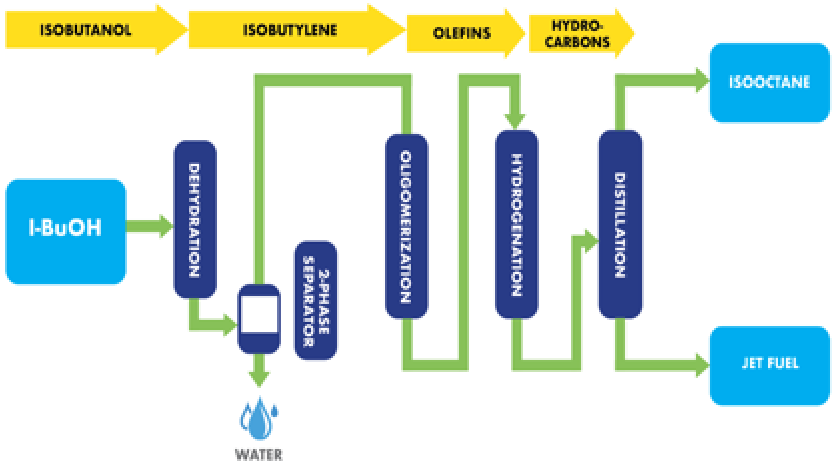
* Operated in Partnership with South Hampton Resources, Inc.

PRODUCTION OF SAF FROM ISOBUTANOL

Technology overview

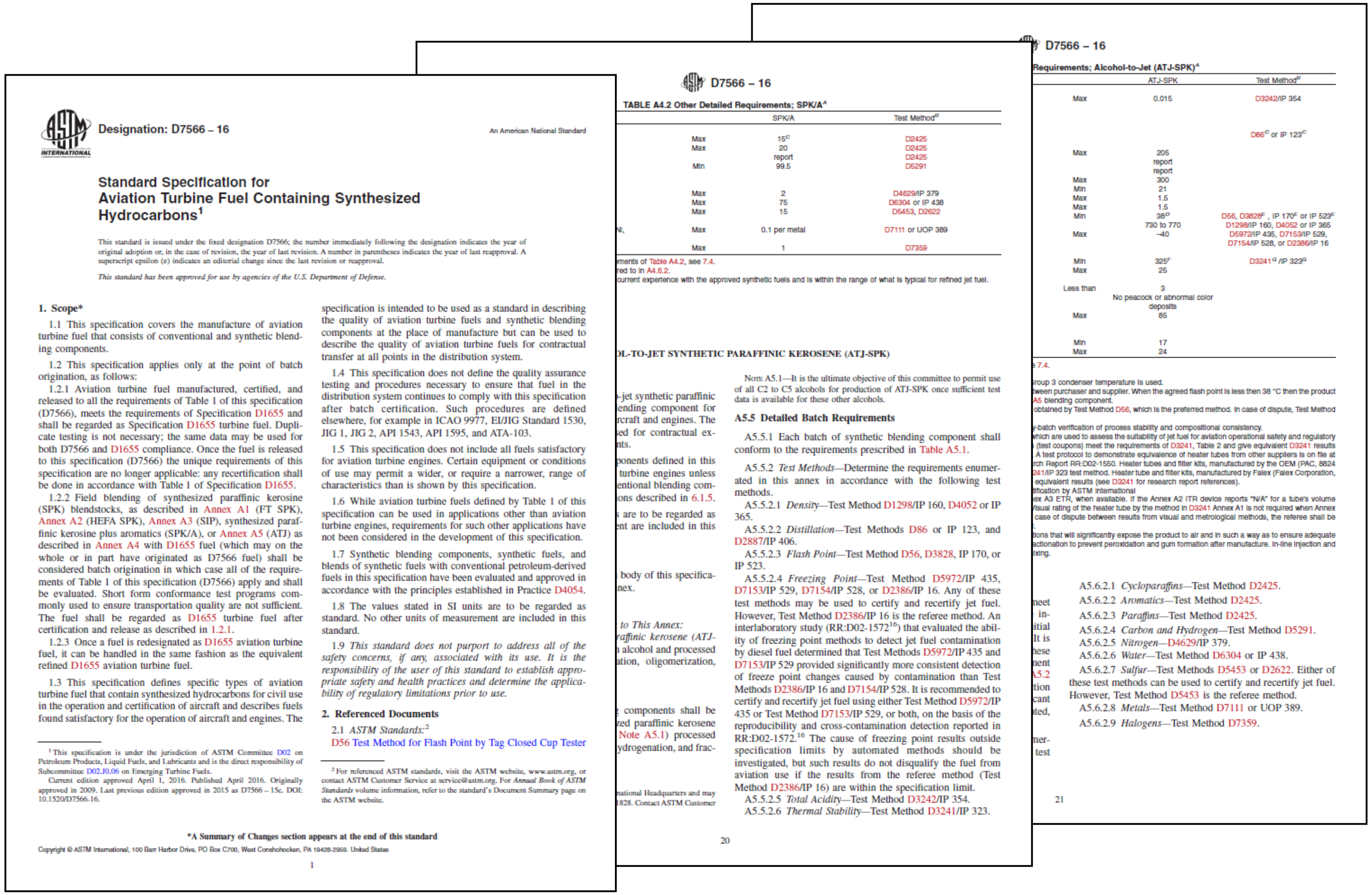
- Simple product mix of isooctane and jet, yields at 98% of theoretical.
- 50/50 jet/isooctane to 80/20 jet to isooctane, same plant different operating conditions
- Gevo has been producing jet fuel and isooctane since 2011 and PX since 2013 at Silsbee, TX demo plant (currently 100,000 gallon per year capacity).
- +35,000 hours operating experience
- Proprietary processing based on standard unit operations leads to high yields, with minimum of co-products.
- Processes work well. 1MGPY plant is designed already. 12MGPY plant is being engineered.

Process Flow



ASTM APPROVED

- Took ~6 years to get approved
- Took 186,000 gallons of fuel
- ATJ plant has run ~35,000 hrs
- Could use any carbohydrate source (starch, sugar, molasses, cellulosic)


Designation: D7566 – 16

An American National Standard

Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons[1]

This standard is issued under the fixed designation D7566; the number immediately following the designation indicates the year of original adoption or, in the case of revision, the year of last revision. A number in parentheses indicates the year of last reapproval. A superscript epsilon (ε) indicates an editorial change since the last revision or reapproval.

This standard has been approved for use by agencies of the U.S. Department of Defense.

1. Scope*

1.1 This specification covers the manufacture of aviation turbine fuel that consists of conventional and synthetic blending components.

1.2 This specification applies only at the point of batch origination, as follows:

1.2.1 Aviation turbine fuel manufactured, certified, and released to all the requirements of Table 1 of this specification (D7566), meets the requirements of Specification D1655 and shall be regarded as Specification D1655 turbine fuel. Duplicate testing is not necessary; the same data may be used for both D7566 and D1655 compliance. Once the fuel is released to this specification (D7566) the unique requirements of this specification are no longer applicable: any recertification shall be done in accordance with Table 1 of Specification D1655.

1.2.2 Field blending of synthesized paraffinic kerosine (SPK) blendstocks, as described in Annex A1 (FT SPK), Annex A2 (HEFA SPK), Annex A3 (SIP), synthesized paraffinic kerosine plus aromatics (SPK/A), or Annex A5 (ATJ) as described in Annex A4 with D1655 fuel (which may on the whole or in part have originated as D7566 fuel) shall be considered batch origination in which case all of the requirements of Table 1 of this specification (D7566) apply and shall be evaluated. Short form conformance test programs commonly used to ensure transportation quality are not sufficient. The fuel shall be regarded as D1655 turbine fuel after certification and release as described in 1.2.1.

1.2.3 Once a fuel is redesignated as D1655 aviation turbine fuel, it can be handled in the same fashion as the equivalent refined D1655 aviation turbine fuel.

1.3 This specification defines specific types of aviation turbine fuel that contain synthesized hydrocarbons for civil use in the operation and certification of aircraft and describes fuels found satisfactory for the operation of aircraft and engines. The specification is intended to be used as a standard in describing the quality of aviation turbine fuels and synthetic blending components at the place of manufacture but can be used to describe the quality of aviation turbine fuels for contractual transfer at all points in the distribution system.

1.4 This specification does not define the quality assurance testing and procedures necessary to ensure that fuel in the distribution system continues to comply with this specification after batch certification. Such procedures are defined elsewhere, for example in ICAO 9977, EI/JIG Standard 1530, JIG 1, JIG 2, API 1543, API 1595, and ATA-103.

1.5 This specification does not include all fuels satisfactory for aviation turbine engines. Certain equipment or conditions of use may permit a wider, or require a narrower, range of characteristics than is shown by this specification.

1.6 While aviation turbine fuels defined by Table 1 of this specification can be used in applications other than aviation turbine engines, requirements for such other applications have not been considered in the development of this specification.

1.7 Synthetic blending components, synthetic fuels, and blends of synthetic fuels with conventional petroleum-derived fuels in this specification have been evaluated and approved in accordance with the principles established in Practice D4054.

1.8 The values stated in SI units are to be regarded as standard. No other units of measurement are included in this standard.

1.9 *This standard does not purport to address all of the safety concerns, if any, associated with its use. It is the responsibility of the user of this standard to establish appropriate safety and health practices and determine the applicability of regulatory limitations prior to use.*

2. Referenced Documents

2.1 *ASTM Standards:*[2]

D56 Test Method for Flash Point by Tag Closed Cup Tester

[1] This specification is under the jurisdiction of ASTM Committee D02 on Petroleum Products, Liquid Fuels, and Lubricants and is the direct responsibility of Subcommittee D02.J0.06 on Emerging Turbine Fuels. Current edition approved April 1, 2016. Published April 2016. Originally approved in 2009. Last previous edition approved in 2015 as D7566 – 15c. DOI: 10.1520/D7566-16.

[2] For referenced ASTM standards, visit the ASTM website, www.astm.org, or contact ASTM Customer Service at service@astm.org. For *Annual Book of ASTM Standards* volume information, refer to the standard's Document Summary page on the ASTM website.

*A Summary of Changes section appears at the end of this standard

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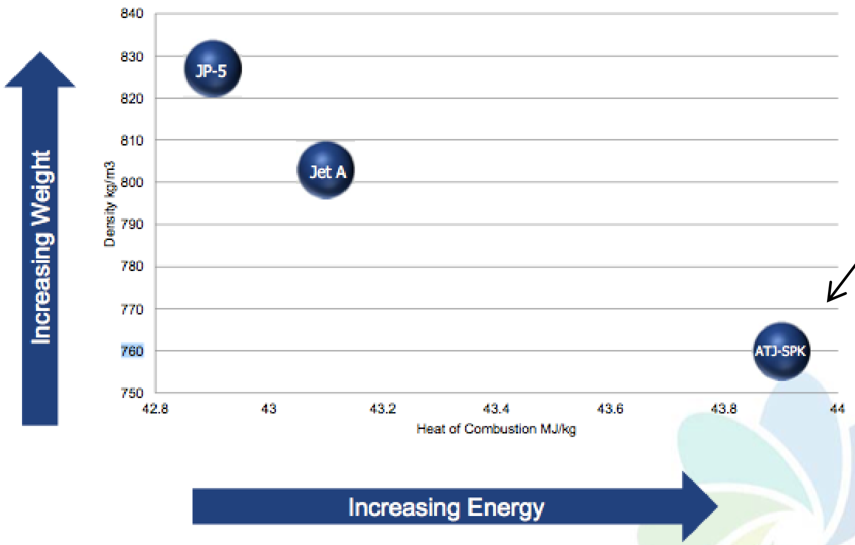
SAF TECHNICAL INFORMATION

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%**

Lower freezing point

Very low sulfur means lower SOx



The energy density of ATJ is 1-2% higher than petro-jet. This means more miles per gallon of fuel, or more weight might be carried by a plane.

PRODUCTS WORK: GEVO JET FUEL

PRODUCTS WORK, WE ARE BUILDING EXPERIENCE

FLY GREEN
Fueled by Gevo

WHAT KIND OF AIRCRAFT HAVE USED OUR FUEL?

Military

- Blackhawk UH-60
- Reaper
- A-10
- F-18
- Chinook
- Others
- See ASTM Appendix for more detail

Commercial

- All airframes since we have been doing “Fly Green Days” where all planes at an airport use a blend of our fuel

Praj – Gevo : End to End Solutions

Innovate • Integrate • Deliver

Thank You

info@Praj.net

www.praj.net