

# Renewable Fuels For All Modes Of Transport



# JET FUEL

## Basic Definitions

- **JET FUEL** “Standalone” hydrocarbon that can be used in turbine engines
- **BLENDSTOCK** Hydrocarbon product that can “only” be used as an additive to FUEL
- **DROP-IN FUEL** JET FUEL that is the result of “Blending” JET FUEL & BLENDSTOCK
- **REPLACEMENT JET FUEL** Alternatively produced JET FUEL requiring “no blending”

# TRANSFORMING AN INDUSTRY CREATING VALUE AT EACH STAGE



- 
- Gasoline
  - Jet Fuel
  - Diesel
  - Heating Oil



FARM  
RESIDUALS



- Electricity
- Fiberboard
- Carbon Fiber
- Animal Feed



FERMENTATION  
RESIDUALS



- Animal Feed
- Omega Oils
- Human Food Proteins
- Chitosan Products



CATALYTIC  
RESIDUALS



- Pure Water

The True  
**BIO-REFINERY:**  
The New AgTech  
Business Model

# FUNDAMENTALS & CHALLENGES

## DEVELOPING AN ALTERNATIVE FUEL INDUSTRY

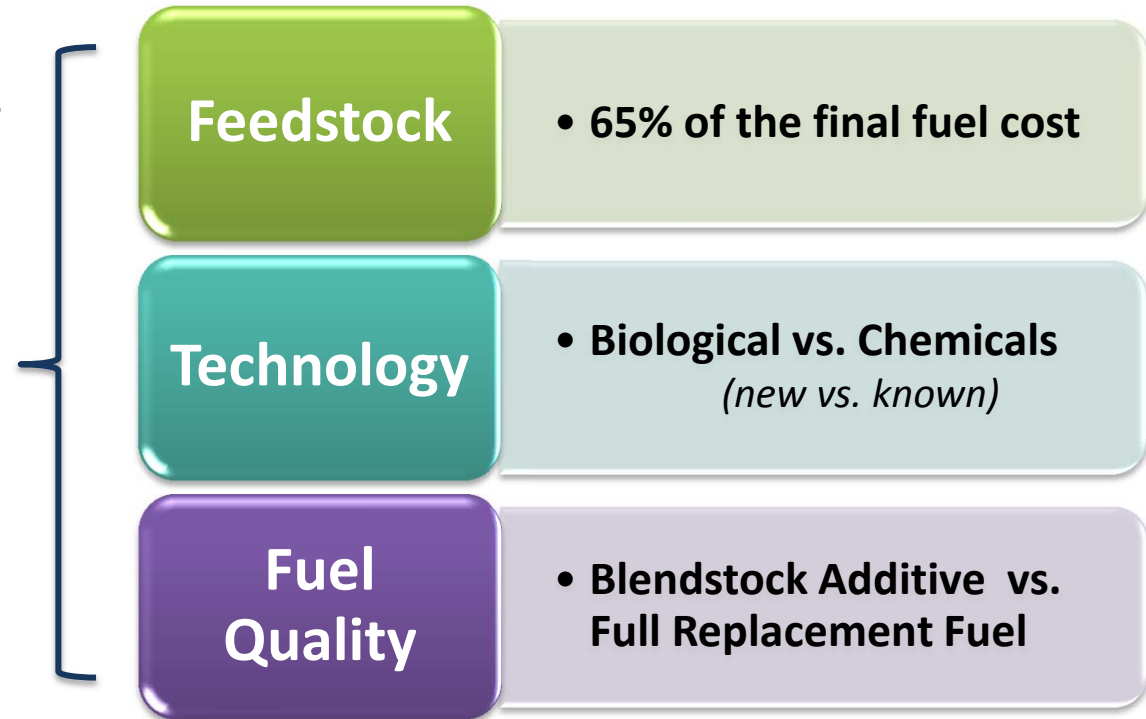
### *Fundamentals*

*“Required” To Achieve Scale & Cost*

*Industry Challenge*



**Scale & Cost**



# ALCOHOL TO JET (“ATJ – SKA”)

*Synthetic Kerosine With Aromatics*

**ADDRESSING INDUSTRY CHALLENGES**



**Feedstock**

**SUGARS**

*Most Abundant Feedstock In The World*

**Technology**

**PETROCHEMICAL**

*Proven Chemical Process (No Magic Bugs)*

**Fuel  
Quality**

**PREMIUM FULL REPLACEMENT FUEL**

*Eliminating Blending Logistic Challenges*

# THE IMPORTANCE OF A FULL FUEL SAFETY & COST



## #1 Misconception ... No Need For A Fully Synthetic Fuel Now

*“Industry is Too Large To Supply Enough Volume”*

- 5 ASTM “Blendstock” specifications since 2009 *(with varying blending limitations)*
- Many additional blendstocks on the horizon
- Will require a global database of every drop
- Minimum 8% aromatics will require adjustments to blend from varying crude specs

**DOWNSTREAM BLENDING LOGISTICS ARE UNDERESTIMATED**

Most Processes  
Bio-Blendstocks



Petro-Fuel

# THE IMPORTANCE OF A FULL FUEL SAFETY & COST

*Adopting a full replacement fuel will save billions \$\$\$ by eliminating the downstream issues of:*

- **Blending**
- **Storage**
- **Transportation**
- **Accounting**

**DOWNSTREAM LOGISTICS COSTS ARE UNDERESTIMATED**

## In The News ....

### **OKLAHOMA : More Than 100 Fuel Retailers Affected by E30 Mix-Up**

*....more than 100 fuel retailers mistakenly received gasoline containing up to 30% ethanol instead of E10, creating chaos throughout the state but especially in the Tulsa and Oklahoma City metropolitan areas.....*





# FAA RECOGNIZES BLENDING LOGISTIC CHALLENGES



U.S. Department of Transportation  
Federal Aviation Administration

## Rolls-Royce Alternative Fuels Program - Final Report

Continuous Lower Energy, Emissions and Noise (CLEEN) Program

Submitted by Rolls-Royce



DOT/FAA/AEE/2015-02

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The Continuous Lower Energy, Emissions and Noise (CLEEN) Program is a Federal Aviation Administration NextGen effort to accelerate development of environmentally promising aircraft technologies and sustainable alternative fuels. The CLEEN Program is managed by the FAA's Office of Environment and Energy.

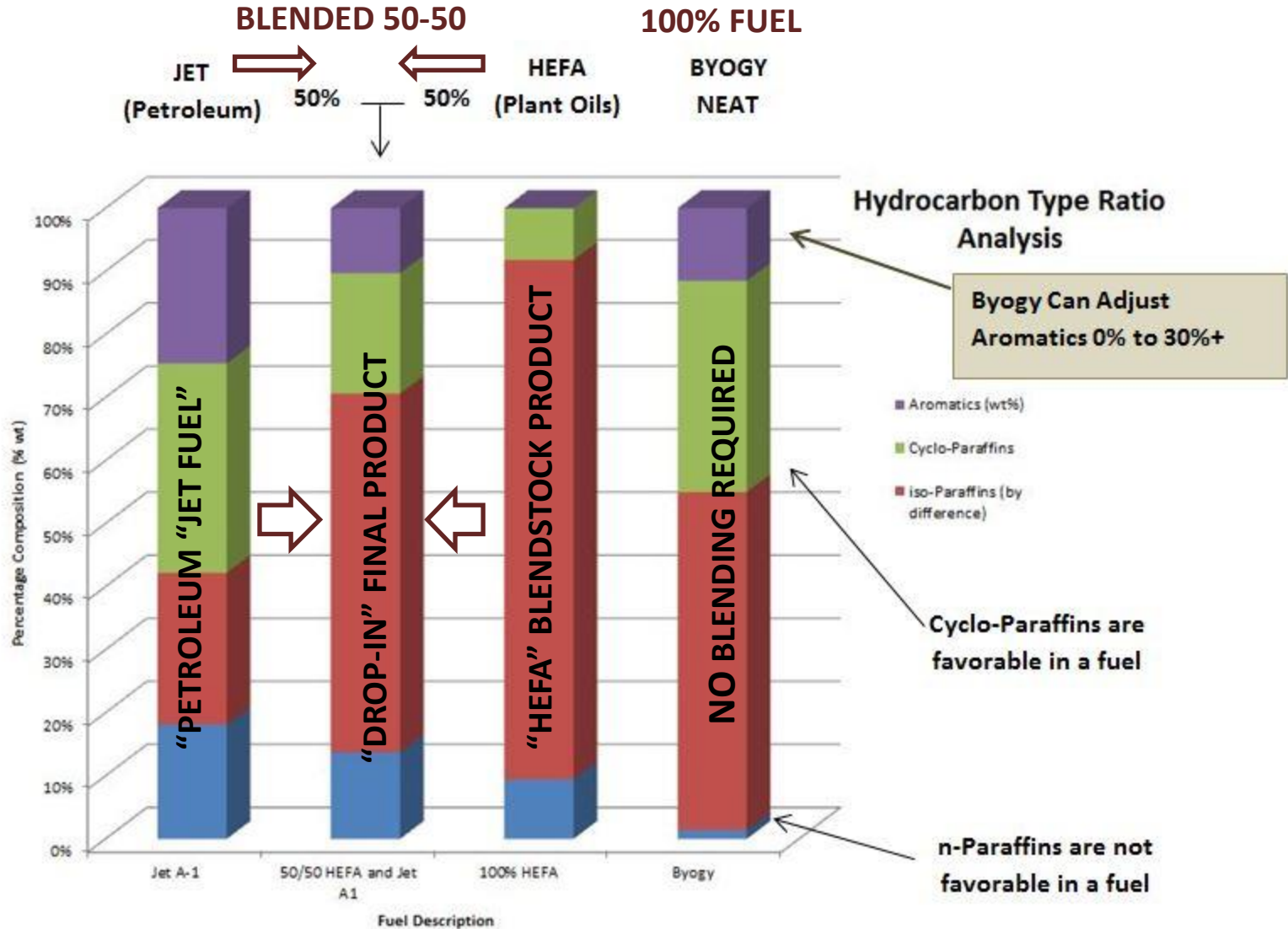
The report presented herein is a report deliverable submitted by Rolls Royce for a project conducted under the CLEEN Program to evaluate the feasibility of selected alternative fuels as viable drop-in replacements to petroleum jet fuel. This project was conducted under FAA other transaction agreement (OTA) DTFAWA-10-C-00006. This is report number DOT/FAA/AEE/2015-02 by the FAA's Office of Environment and

Rolls-Royce Alternative Fuels Program - Final Report

Table 2 – Candidate Fuels Selected for Rig Testing

	Supplier	Fuel Type and Description		Aromatic content
Baseline blends	UK Jet A-1 / Dynamic Fuels HEFA	Jet A-1 (baseline)	100% Conventional	17.3%
		HEFA / Jet A-1	50/50 Blend (ASTM D7566)	8.6%
		HEFA / Jet A-1	75/25 Blend	4.3%
		100% HEFA	100% HEFA	0.1%
Novel fuels	Byogy	Alcohol to Jet	Novel Single Process No1	9.4%
	ARA	Catalytic Hydrothermolysis	Novel Single Process No 2	15.8%
	Shell / Virent	GtL + Sugar Bio-forming	Novel Blend No 1	13.4%
	Algaeon / Swift	Cellulose - Aromatic + SPK	Novel Blend No2	19.7%

# Byogy Fuel Testing Results From FAA CLEEN



# BYOGY FUEL TESTING

Proves **PREMIUM** Full Replacement Fuel



## BYOGY's ATJ-SKA Testing:

- FAA CLEEN Program
- USAF
- SASOL
- PRIVATE

*All testing validated a “premium full replacement aviation fuel”*

- ✓ **Better Fuel Burn Efficiency (“SFC”)** *(greater miles per gallon)*
- ✓ **Reduce GHG by >80%**
- ✓ **Delivers lower engine maintenance costs** *(negligible n-paraffins)*
- ✓ **Has lower freeze temperature** *(opening up new flight space)*
- ✓ **Can adjust aromatics to any level** *(to adapt to local crude oil specs)*

# ASTM : Alcohol To Jet – Advanced Testing

## ALCOHOL-TO-JET (ATJ) SPECIFICATIONS

ATJ CORE APPROVED

ATJ – SPK-1 Iso-Butanol (30% max)

ATJ AMENDMENT #1

ATJ – SPK-2 Ethanol & n-Butanol (50% max)

ATJ AMENDMENT #2  
Or New Annex

ATJ – SKA-1  
Ethanol & Butanol  
(50% max)

### Mil-Spec & ADVANCED TESTING PROGRAM

ATJ – SKA ADVANCED TESTING TO DEVELOP A SPECIFICATION FOR UP TO 100%

*(Subsequent and/or parallel processing to be introduced at ASTM to achieve higher blends than 50% once sufficient “experience” data is collected)*

MIL-SPEC &  
ATJ-SKA 2  
100% Circa 2019/21

ATJ SKA – 100% FULL FUEL

2016

2017

2018

2020/2022

# Byogy Commercializes at Every Level Of ATJ



ATJ ASTM MILESTONE	PROJECTED <sup>1</sup> TIMEFRAME	FEEDSTOCK	AROMATICS	BLEND Max	BYOGY APPLICABILITY (Commercial Viability)
SPK - 1	2015	Iso- Butanol	NO	30%	
SPK - 2	2016/17	Ethanol N-Butanol Mixed Alcohol	NO	50%	
SKA - 1	2017/18	Ethanol, Butanol	YES	50%	
SKA - 2	~ 2018-2020	Ethanol, Butanol	YES	100%	

<sup>1</sup> Best estimation based on Byogy ASTM participation – subject to ASTM process



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