Canadian Efforts in Support of Sustainable Aviation Fuels

- **Environment and Climate Change Canada**
  - Carbon pricing
  - Clean Fuel Standard
- **Transport Canada**
  - ICAO, ASCENT, CAAFI
  - Action Plan for Aviation GHG *SAJF
  - Research activities
  - Federal offtake
- **Natural Resources Canada**
  - Sky's the Limit Challenge
  - Federal offtake
  - Trilateral work (Can-US-Mexico)
  - Canadian Forest Service (feedstocks)
  - Related funding programs (eg. Carbon Engineering)
- **National Research Council**
  - Combustion research and engine testing
  - Atmospheric research and flight testing
- **Agriculture Canada**
  - Bioeconomy
  - Agricultural feedstocks (crops / residues)
- **Dept. of National Defence**
  - Research and flight testing
  - Federal offtake
- **Sustainable Development Technology Canada**
  - Enerkem / Agrisoma
- **Provincial Programs**
  - SBI Bioenergy
  - WestJet Challenge

The Sky's the Limit

Overview of NRCan's Sustainable Aviation Fuel Challenge

Presented by Jason Gadoury
Director of Program and Policy Innovation, Natural Resources Canada

Natural Resources Canada | Ressources naturelles Canada

Canada

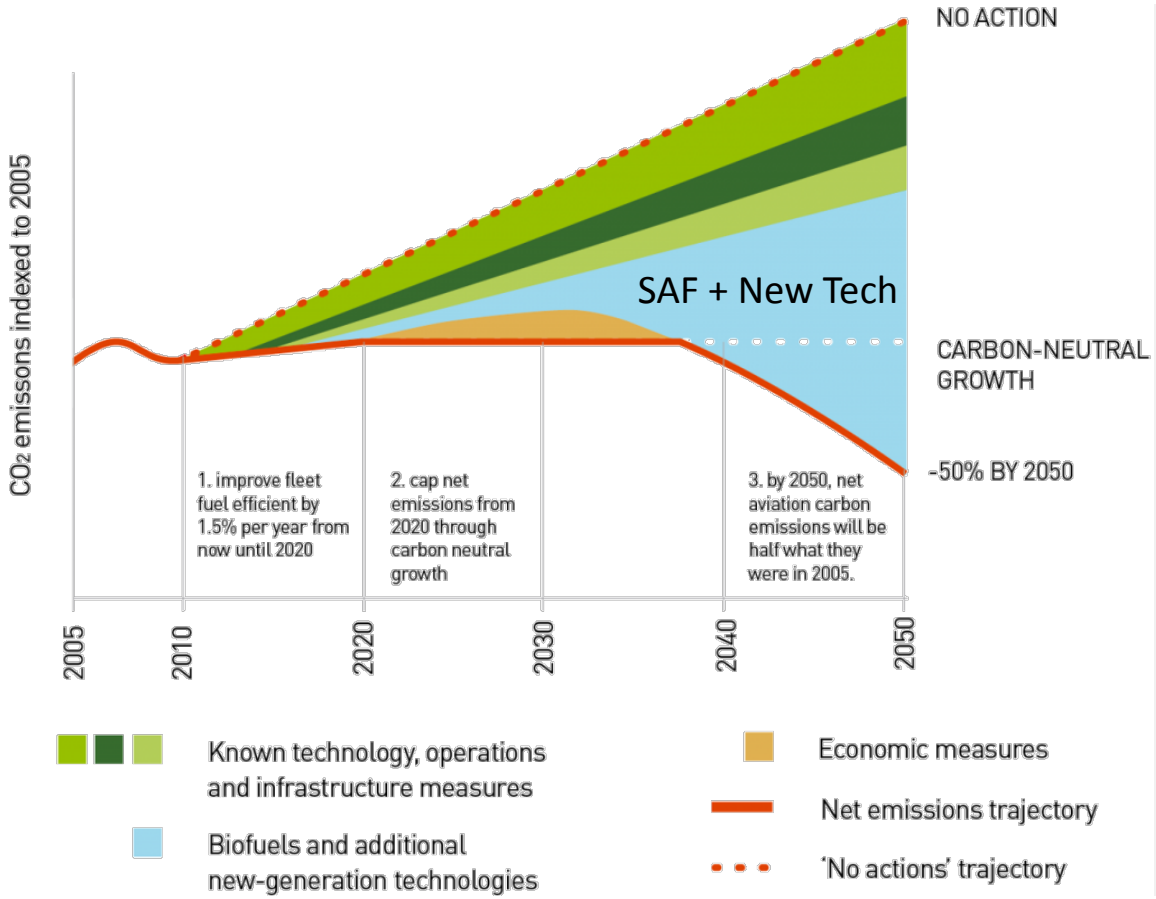
GARDN
Green Aviation Research & Development Network

AIR CANADA

WESTJET

Why are we doing the Challenge?

Sustainable Aviation Fuel (SAF): A Low-Carbon Pathway for Aviation



- **Pan-Canadian Framework:** reduce emissions 30% below 2005 levels by 2030 (includes cleaner fuels).
- **Canadian and international airlines:** carbon neutral growth as of 2020 and 50% reduction in CO2 emissions by 2050.
- **Aviation is a growing industry:** traffic to increase 4-5%/year until 2030 and fuel consumption up by more than 51% since 1995.
- **Improvements from technology is not enough:** aircraft efficiency improvements can only compensate for 50% of additional fuel demand (37% improvement/100km since 1995).
- **SAF is crucial to greening aviation and Canada's transition to a low carbon economy.**

What are we hoping to achieve?

Key Objectives:

- **Accelerate innovation** to bring down the cost of sustainable aviation fuel and reduce GHG emissions from air transportation.
- **Build on Canadian strengths** (e.g., forestry, agriculture, fuel production, innovation) to develop a world-class supply chain for the production of SAF.
- **Support Canadian leadership in clean technology innovation** and the growing global market for green fuels.
- **Promote the use of Canadian-made SAF** in domestic commercial flights in Canada.

THE SKY'S THE LIMIT CHALLENGE

Green Aviation Fuels Innovation Competition

ITINERARY

AUGUST 2018	CALL FOR PROPOSALS IS NOW OPEN. APPLY TODAY!
FEBRUARY 2019	DEADLINE TO SUBMIT YOUR PLAN
MAY 2019	TOP FOUR TEAMS ANNOUNCED
NOVEMBER 2020	10L BIOJET FUEL SUBMISSION
MARCH 31, 2021	GRAND PRIZE WINNER ANNOUNCED

Now Boarding

Check In
Join a team and submit your plan.
Top four teams win $2M
to help their idea take flight.

Layover – Make your Connection!

Join us at the upcoming forum where participants can meet with the best of the green aviation fuels industry, from investors to airlines.

Arrivals – Grand Prize Competition

The Grand Prize of $5 million will help the team with the best green aviation fuel commercialize their innovation.

THE SKY'S THE LIMIT CHALLENGE

Cross-Canada Flight Competition

3,000 KM FLIGHT

MARCH 2019	The competition begins!
JANUARY 2021	Competition closes
BY MARCH 31, 2021	$1 million winner announced

Produce the required biojet fuel in Canada and let us know

The first producer to meet all the criteria for their "Made-in-Canada" biojet fuel will **win $1 million**.

Who can apply:

1. **The Green Aviation Fuels Innovation Competition is open to Legal entities validly incorporated or registered in Canada, including:**
   - For-profit and not-for-profit organizations
   - Indigenous organizations and groups
   - Canadian academia

2. **The Cross-Canada Flight Competition is open to sustainable aviation fuel producers duly incorporated and validly existing in Canada.**

Non-Canadian individuals and entities may be part of a partnership or consortium.

Green Aviation Fuels Innovation Competition

Develop a made-in-Canada SAF with the best GHG reduction, the lowest production cost, and the greatest potential for commercial scale-up by 2021

Round 1: Finalists

Up to $2M in project support per finalist

August 17, 2018:
Call for proposals is open

November 13, 2018:
Sky's the Limit Challenge Forum

February 1, 2019:
Deadline to submit your plan

By May 31, 2019:
Four finalists announced

Application requirements:

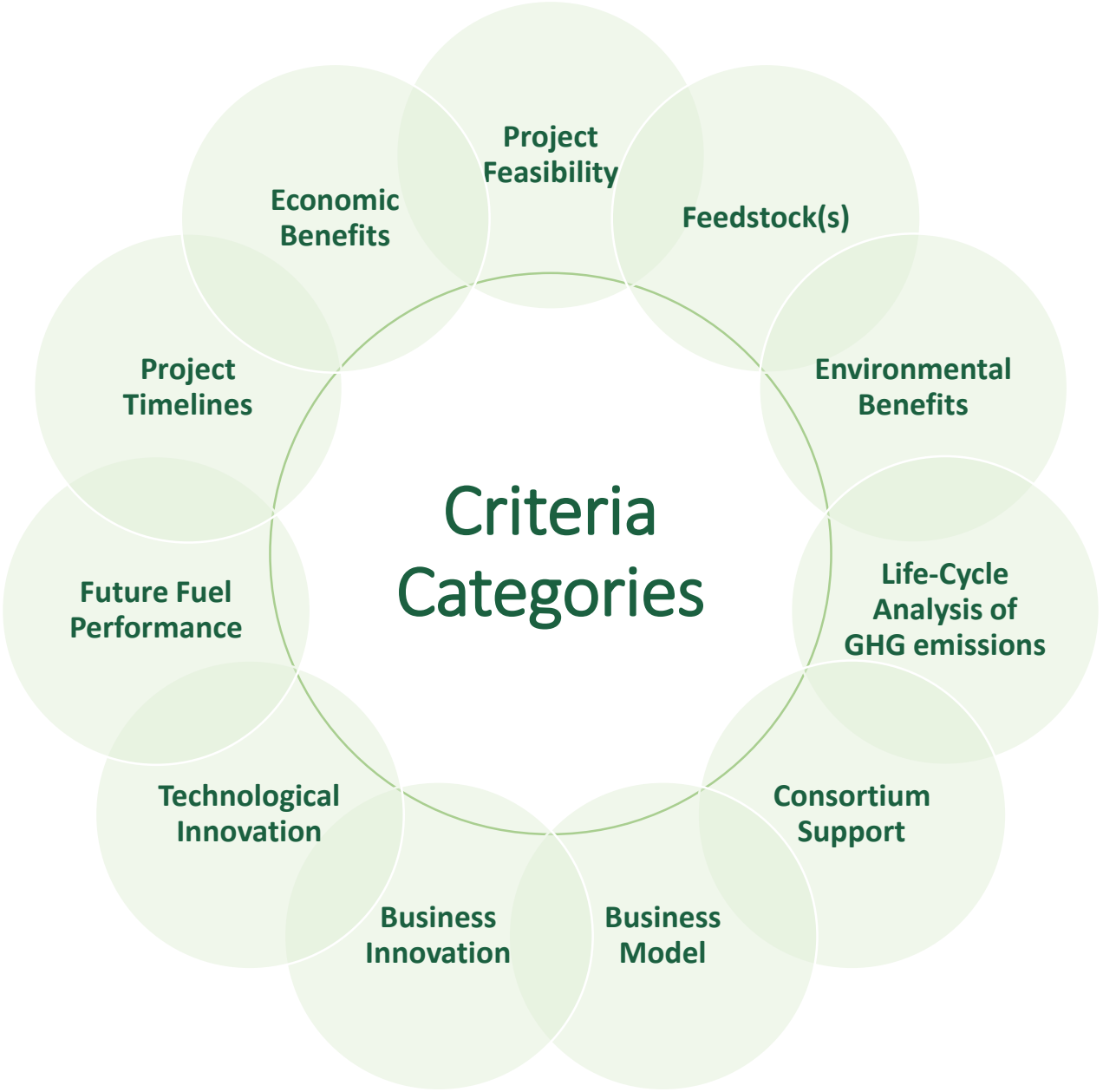
- Supporting documentation for eligibility
- Supporting documentation for IP
- Detailed proposal
- Risk mitigation plan
- Financial risk assessment
- Information on existing funding

Submit a Plan that includes:

- Consortium-building capacity
- Technological innovation
- Business innovation
- Supply chain integration
- Resource commitment and approach to developing Canadian SAF by 2021

Evaluation Criteria:

Each submission must provide sufficient details to enable assessment



Green Aviation Fuels Innovation Competition

Round 2: Winner

$5M Prize

By May 31, 2019:
Four finalists announced

November 1, 2020:
Final prize submission deadline

By March 31, 2021:
Final prize winner announced

Each applicant must provide:

- A minimum of 10 litres of SAF
- Confirmation from an auditing company in Canada that the applicant is the producer of the SAF

The SAF providing the best combination of:

- Highest potential for GHG emissions reduction based on LCA
- Lowest production cost
- Best scale-up potential
- Best economic benefits to Canada

Cross-Canada Flight Competition

First Canadian SAF producer to supply made-in-Canada SAF for use in a commercial flight :

- 2500 Litres of SAF meeting CGSB/ASTM standards, with GHG emissions that are a minimum of 10% lower than that of conventional aviation fuel, delivered to a Canadian airport
- Air Canada/WestJet Cross-Canada flight (approx. 3000 km) with a minimum of 10% blend (10% SAF)
- Achieves a Canadian first, establishes proof of concept for a SAF supply chain in Canada, and increases awareness of SAF as part of the climate change solution

Cross-Canada Flight Competition

$1M Prize

March 1, 2019:
Competition begins

June 30, 2019:
Prize awarded start date

January 1, 2021:
Competition closes

March 31, 2021:
Prize awarded closing date

Application Requirements:

- Confirmation that the SAF meets CAN/CGSB 3.23-2016 and ASTM D7566
- Confirmation that the GHG emissions are a minimum of 10% lower than that of CAF on a life-cycle basis
- Confirmation that all of the SAF was produced in Canada
- Information on existing funding

The first SAF producer to provide NRCan with:

- Confirmation from airline(s) with a specific date for the Cross-Canada Flight, conditional to:
  - A minimum of 2,500 L of SAF blended are delivered the day of the flight
  - A flight with a minimum 10% blend has happened

Online Resources

Website (Applicant Guide, FAQs, to apply…) :
https://impact.canada.ca/en/challenges/green-aviation/

Send us your questions at: nrcan.cleantechimpact-impacttechpropres.rncan@canada.ca

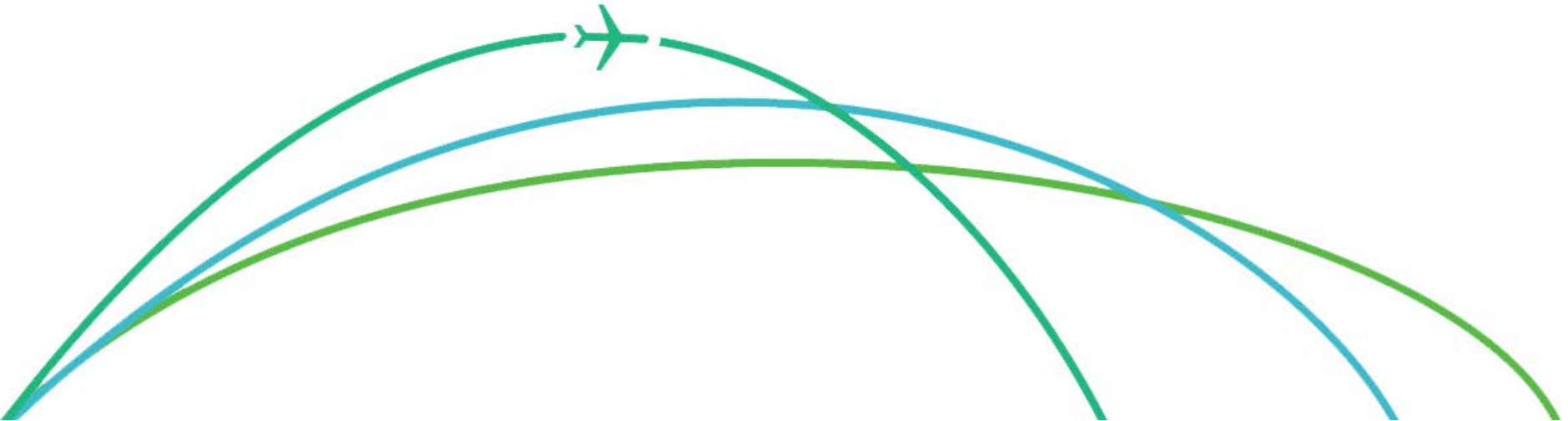
Join the conversation using #CleantechImpact and #GreenAviation

GARDN

Green Aviation
Research & Development
Network

Groupement Aéronautique
de Recherche et Développement
en eNvironnement

History and current projects



FINANCIAL PARTNER

Government of Canada
Networks of Centres of Excellence

Gouvernement du Canada
Réseaux de centres d'excellence

The first green aviation initiative in Canada

First commercial flight in Canada powered by biofuels

World's first civil aircraft powered entirely by biofuels

Flight management system expertise by CMC Electronics and École de Technologies Supérieures.

Biofuels as a drop-in fuel at Pearson Airport's hydrant systems in April 2018 (a first in Canada): a project that brought together 14 stakeholder including foreign contributors.

GARDN I & II Members, Contributors and Participants

GARDN projects on sustainable aviation fuels

Innovations along the supply chain: transforming ideas into economic value

AGR-1: Evaluation of bio-SPK production from a new Canadian feedstock crop, *Brassica Carinata*.

TGC1: Biologic and process technologies for Renewable Jet Fuel.

WG-22: Civil Aviation Alternate Fuel Contrail and Emissions Research (CAAFCER).

NEC-21: Assessment of likely Technology Maturation pathways used to produce biojet from forest residues (ATM project).

WG-21: Canada's Biojet Supply Chain Initiative (CBSCI) for enabling 2020 carbon-neutral growth.

GARDN's Role

Green Aviation Research and Development Network

GARDN plays an active leadership role in the advancement of sustainable aviation fuels for Canada.

- Facilitating and promoting new collaborations and connections across the different sectors and components of the SAF supply chain;
- Engaging with green aviation stakeholders in the form of events, meetings, teleconferences, webinars, and workshops; and
- Supporting participants during the Challenge by providing them with virtual tools to share information and facilitate real-time interactions between them.

GARDN Conference 2018

Sky's the Limit Challenge Forum

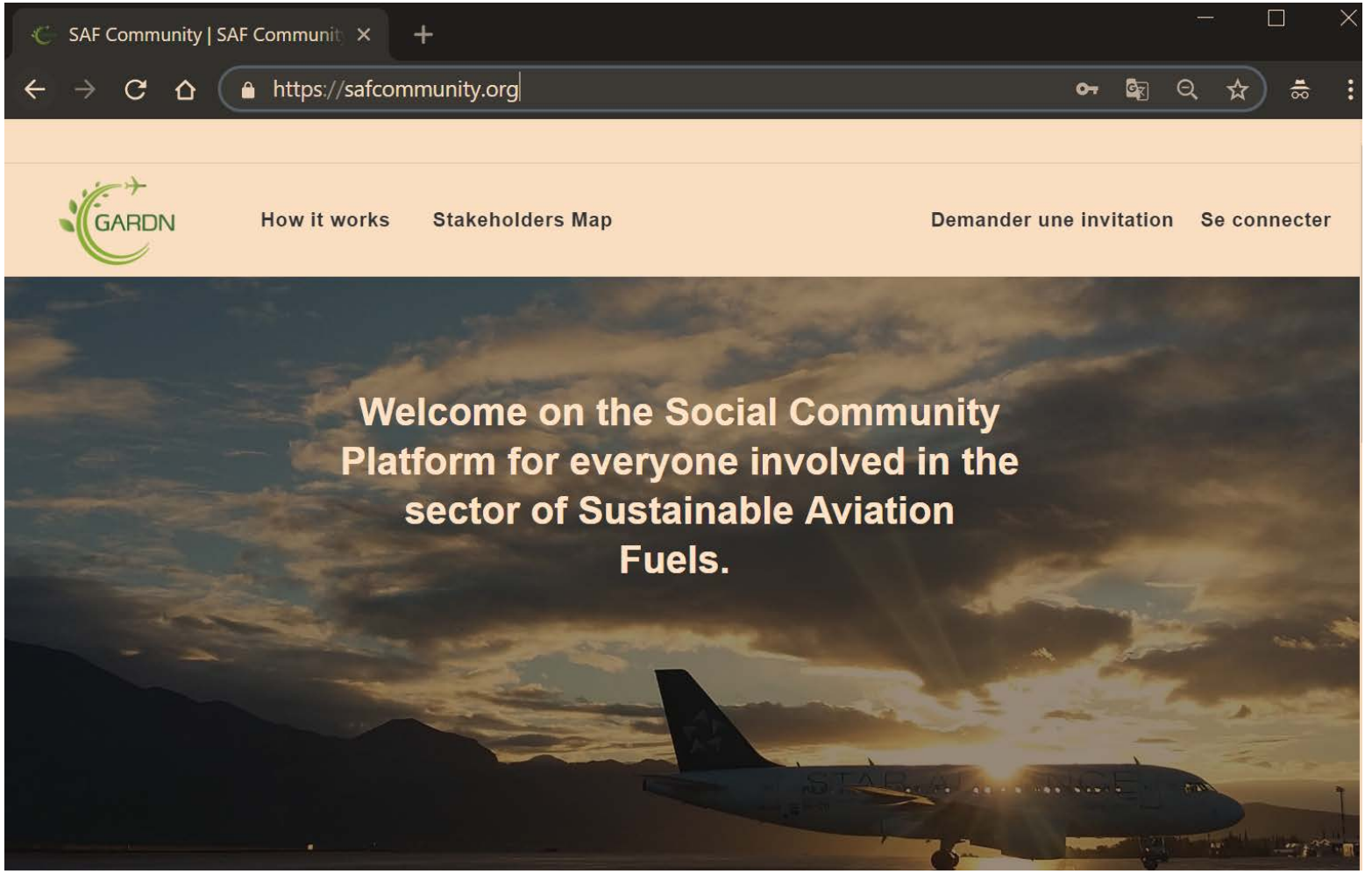
November 13-14, 2018

EVENT GOALS/OBJECTIVES

- To inform potential participants about the Challenge
- connect innovators with partners and investors
- provide space for innovators to share and promote their projects
- provide expert advice from business and tech resources

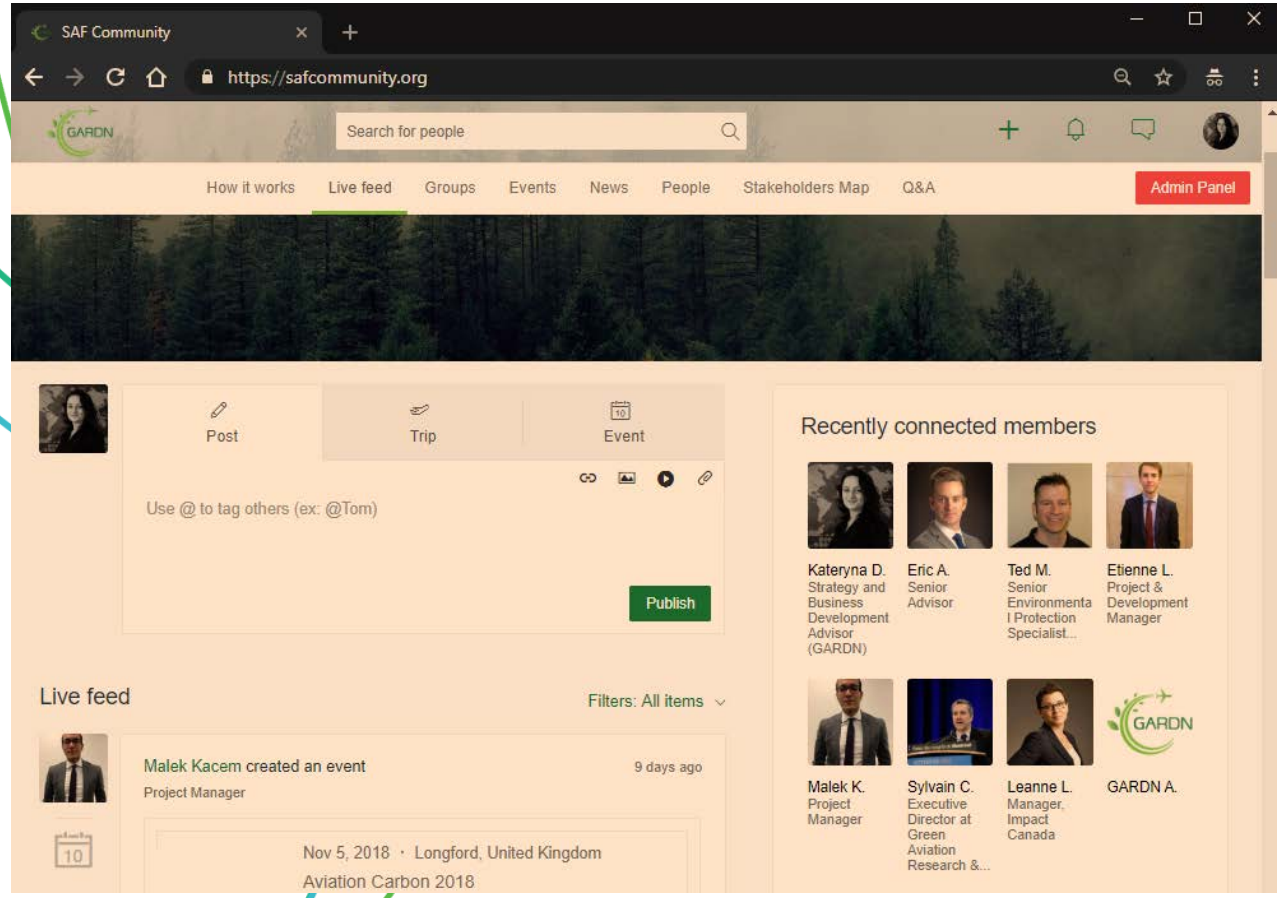
GARDN's SAF online community platform

SAFcommunity.org



5. SAF Community

Create a virtual proximity with your professional network



- Facilitate collaboration and increase business opportunities
- Get engaged on conversations that matters to you through forums and interest- specific discussion groups
- Access the latest news, events, funding opportunities and plenty of other useful knowledge about your sector

AIR CANADA

CBSCI
Canada's Biojet Supply Chain Initiative

GARDN
Green Aviation Research & Development Network

ASCENT
AVIATION SUSTAINABILITY CENTER

RÉSEAU BIOFUELNET CANADA

BOEING

CAAFI
COMMERCIAL AVIATION ALTERNATIVE FUELS INITIATIVE

IATA

McGill

Canada
NRC·CNRC

Queen's University

SkyNRG

Transport Canada
Canada

UNIVERSITY OF TORONTO

waterfall group

1

Demonstrate the operational feasibility of biojet fuels in the domestic jet fuel supply system using existing delivery infrastructure (e.g., co-mingled airport fuel system).

2

Validate Canadian biojet supply chain elements (e.g., quantitative feedstock availability, sustainability certification, biojet integration in the jet fuel supply system, quantify regulatory/fiscal options).

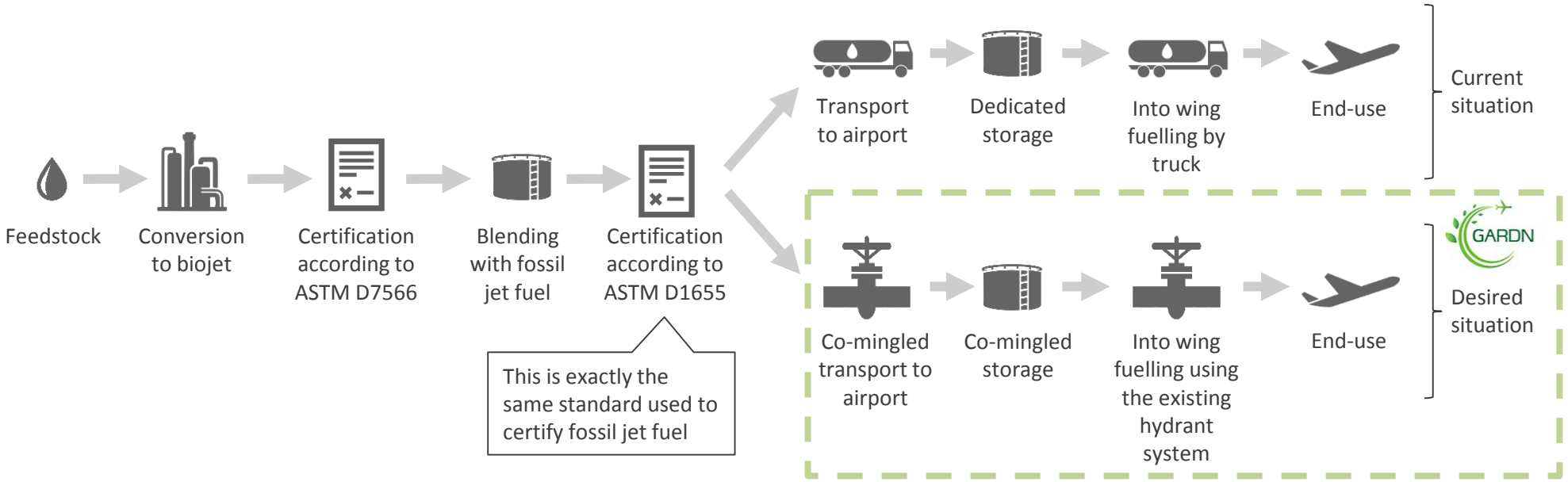
3

Generate hands-on experience with biojet integration to develop best practices in a Canadian context.

4

Catalyze the development of the domestic biojet sector by using HEFA biojet as an enabling mechanism to create market access, drive research, development, and commercialization of advanced biofuel feedstocks and conversion technologies beyond the 2020 timeframe.

Canada’s Biojet Supply Chain Initiative (CBSCI)



CBSCI – Canada's first integrated SAF supply chain!

CBSCI
Canada's Biojet Supply Chain Initiative

SkyNRG

GARDN Green Aviation Research & Development Network

AltAir Fuels

AIR CANADA

EPIC FUELS

Toronto Pearson

ventura TRANSFER COMPANY

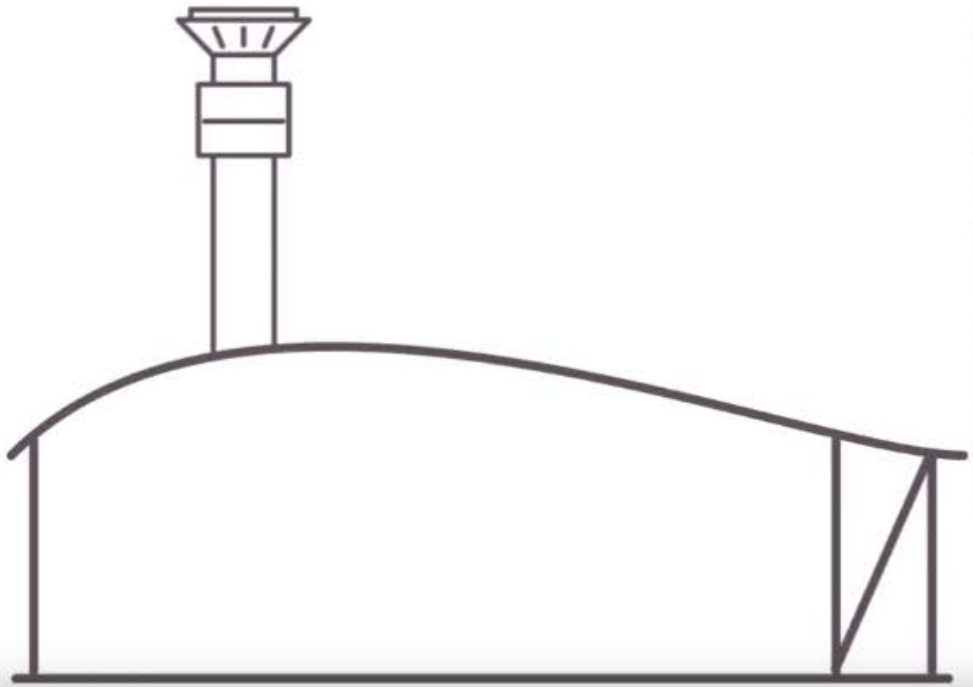
ASIG BY MENZIES AVIATION

1 Feedstock sourcing	2 SAF production	3 Blending with fossil jet fuel	4 Loading in rail cars	5 Transport to airport	6 Supply into fuel farm	7 Fueling flights
▪ UCO sourced domestically	▪ Neat HEFA fuel by AltAir	▪ Fossil jet fuel is sourced locally ▪ 30% SAF blend by AltAir	▪ Trucked to rail yard ▪ Transferred into rail tank cars	▪ Rail car transport to Toronto Airport's fuel farm ▪ SAF rail cars merged with fossil jet train	▪ SAF unloaded into airport's commingled fuel farm	▪ Fuelling via hydrant system ▪ All aircraft receive some SAF ▪ Air Canada claims SAF usage

SkyNRG

Canada’s Biojet Supply Chain Initiative (CBSCI)

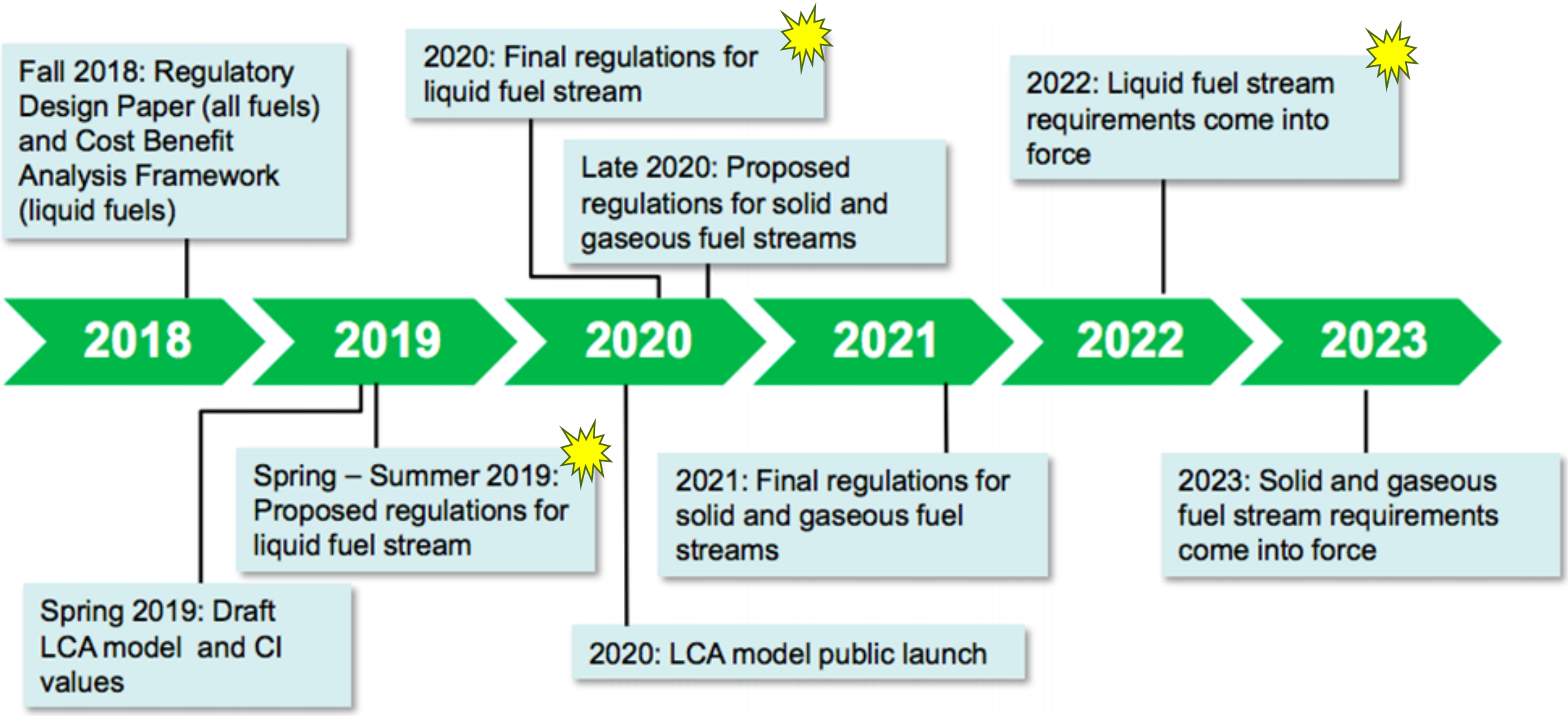
Earth Day 2018 Flights with Biojet



Flight	DEP	ARR	DATE 2018	DEP	ARR	Type
AC480	YYZ	YUL	SU 22 APR	6:30	7:42	320
AC133	YYZ	YYC	SU 22 APR	7:00	9:16	7M8
AC400	YYZ	YUL	SU 22 APR	7:00	8:12	320
AC259	YYZ	YWG	SU 22 APR	8:00	9:37	E90
AC402	YYZ	YUL	SU 22 APR	8:00	9:12	321
AC137	YYZ	YYC	SU 22 APR	8:10	10:25	7M8
AC442	YYZ	YOW	SU 22 APR	8:10	9:10	E90
AC404	YYZ	YUL	SU 22 APR	9:00	10:12	320
AC139	YYZ	YYC	SU 22 APR	10:00	12:16	7M8
AC406	YYZ	YUL	SU 22 APR	10:00	11:12	320
AC261	YYZ	YWG	SU 22 APR	10:05	11:37	319
AC446	YYZ	YOW	SU 22 APR	10:10	11:10	E90
AC107	YYZ	YVR	SU 22 APR	10:15	12:20	320
AC408	YYZ	YUL	SU 22 APR	11:00	12:12	320
AC410	YYZ	YUL	SU 22 APR	12:00	13:12	320
AC450	YYZ	YOW	SU 22 APR	12:10	13:10	E90
AC143	YYZ	YYC	SU 22 APR	12:45	15:01	7M8
AC111	YYZ	YVR	SU 22 APR	12:45	14:50	319
AC263	YYZ	YWG	SU 22 APR	12:55	14:32	E90
AC452	YYZ	YOW	SU 22 APR	13:10	14:10	320
AC145	YYZ	YYC	SU 22 APR	14:40	16:56	7M8

SkyNRG

Clean Fuel Standard: Current Timeline



Source: ECCC – July 19, 2018

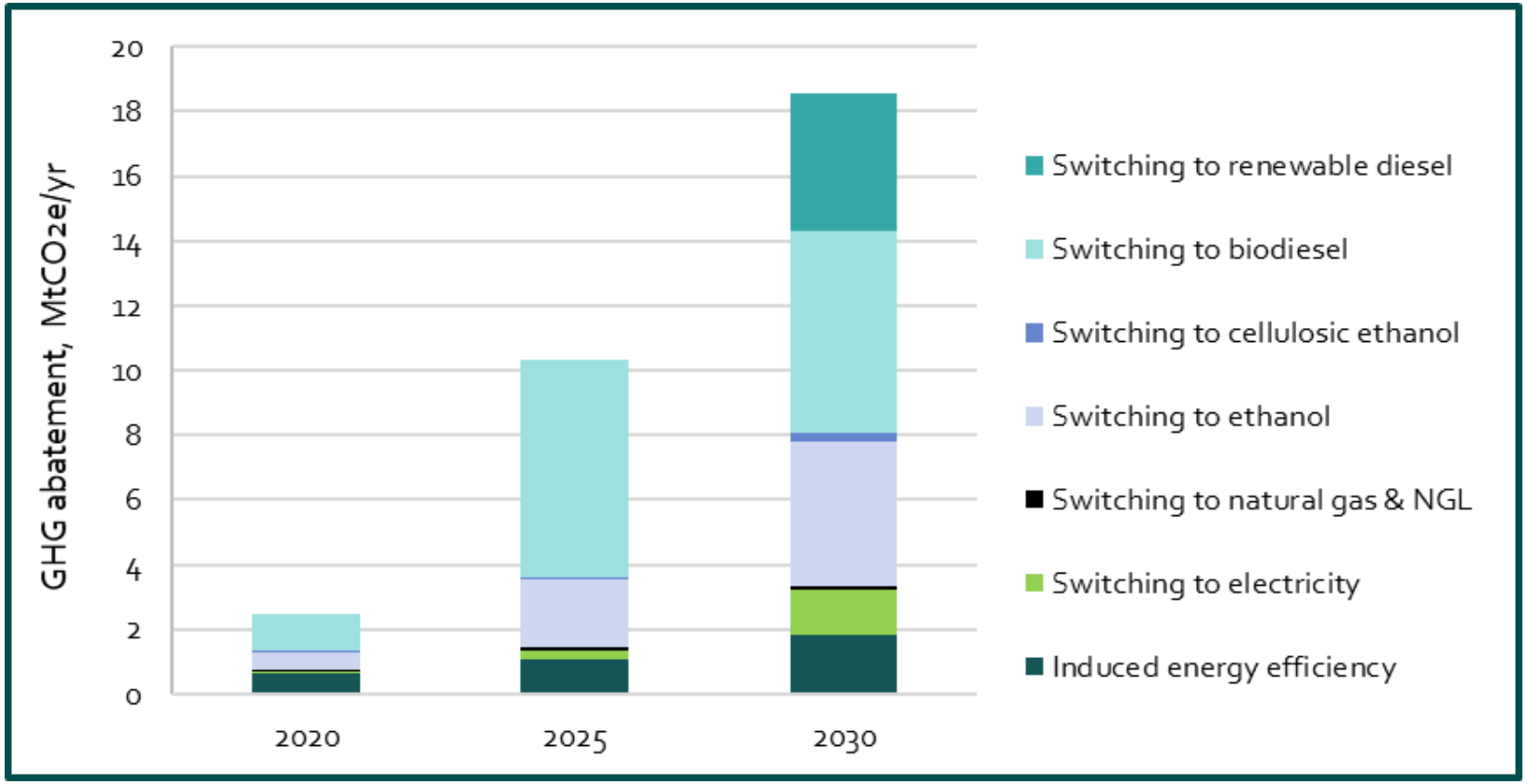
Clean Fuel Standard – Liquid Fuel Stream

- Transportation fuels are 80% of liquid fuels used in Canada

- 2016 biofuel blend rates:
  - Gasoline pool - 6.2%
  - Diesel pool - 1.8%

- 2030 biofuel blend rates:
  - Gasoline pool - 15.0%
  - Diesel pool - 13.5%

Transportation Emission Reductions by Fuel (CFS)



Sources: Clean Energy Canada, Navius Research, 2017

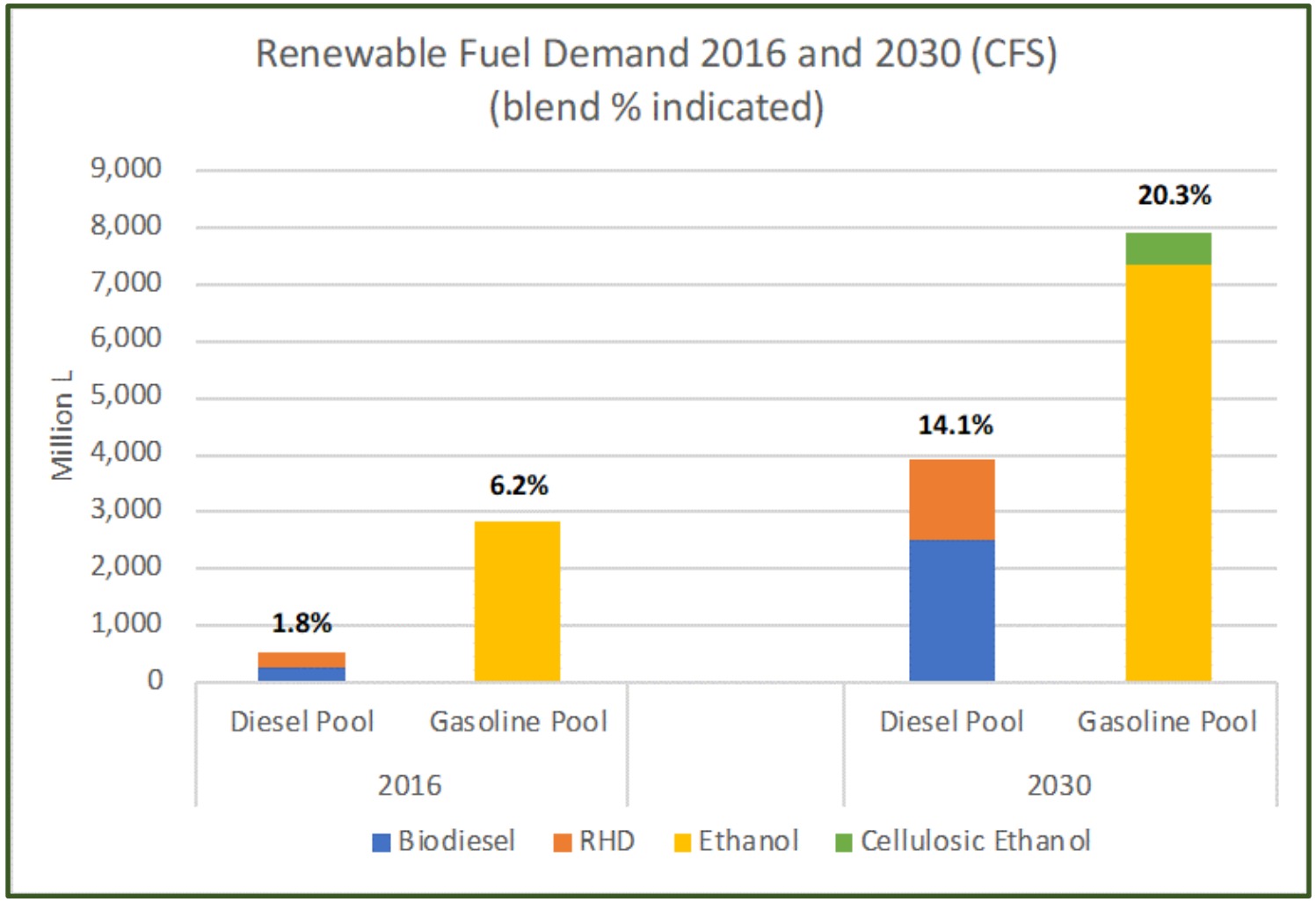
Advanced Biofuels Canada
Biocarburants avancés Canada

Clean Fuel Standard: Takeaways

1. Demand for low carbon liquid biofuels in Canada will increase significantly to 2030

2. No clear picture of the market signal until summer 2019

3. Investments in new capacity target markets with:
   - Feedstock
   - Fuel demand (RFS/LCFS)
   - Competitive programs



Sources: Advanced Biofuels Canada: 20MTY Liquid Fuel Stream Scenario

Advanced Biofuels Canada
Biocarburants avancés Canada

Clean Fuel Standard: Aviation Fuels

Provisional approach to aviation fuels released October 16 2018

ECCC clarified that:

- Aviation gasoline would be excluded from the regulation.
- Domestically used aviation jet fuel would be included as part of the obligation for fossil fuel producers and importers and jet fuel used on international flights would be excluded.

- Includes biojet blending rate (equivalents):
- Compliance with CFS obtainable through CFS credits, low CI fuel blending
- TBD if/what the demand signal is for biojet

Blend %	Fuel Volume (million litres per year)
1%	34
1.5%	50
4%	200
9.5%	350

FORGE Hydrocarbons Corporation

2018 CAAFI Biennial General Meeting

December 6, 2018

FORGE Hydrocarbons Overview

1. Introduction
2. How did we get here?
3. Technology
4. Sombra project (First Plant: pre-commercial demonstration)

FORGE HYDROCARBONS

FORGE Demonstration Plant

Introduction

FORGE Hydrocarbons Corporation has Developed a Lipid-to-Hydrocarbon ("LTH") technology that transforms low-value fats, oils and greases into a Low Carbon Intensity renewable fuel

- FORGE's patented technology produces a fuel that:
  1. Invented by Dr. David Bressler University of Alberta
  2. Is "drop-in" i.e. indistinguishable from a petroleum based fuel such as renewable hydrocarbon diesel (RHD), renewable naphtha, jet fuel
- A pilot plant was commissioned in 2014 with a capacity of 200,000 litres per year of renewable fuels
- The Company's **primary objective is to construct a first-of-kind, commercial plant** with a production capacity of 28 ML/y, and replicate it throughout the world
- FORGE **has managed to raise ~ $20m in non-dilutive** capital
- First plant will be a wholly owned subsidiary of FORGE Hydrocarbons Corp.
- FORGE's roll-out strategy post Scale up (SPV 1) is to Build Own Operate plants on our own or with partners

Feedstock – is EVERYTHING!

FORGE is feedstock "Agnostic" (0%-100% FFA)

- Any of the traditional feedstocks currently used in the Biodiesel and Renewable Diesel
- From 0%-100% without pretreatment
- Able to tolerate high levels of metals (i.e. Sulphur, phosphate etc.) without pretreatment

Smaller Distributed Model (no Hydrogen or catalyst)

- This allows the ability to move "up stream" and co-locate at places to secure feedstock less transport
- Partnering with large ethanol plant provides massive roll-out opportunity
- Partnering with mid tear Renderers eliminates threat of massive RHD plants that are underway

Feedstock – is EVERYTHING!

Higher margins - Low cost provider and Lower CI

- The Fats and oil industry is very efficient it will get more and more competitive
- Higher margin ensures you can always buy feedstock

FORGE is undergoing further R&D to use other novel Lipid sources; such as

- **Algal oil** from MARA Renewables Corp.
- **Tall Oil** Canadian Pulp and Paper company to assist
- **Biosolids** materials produced during treatment of sewage sludge, as a feedstock for fatty acid.
- **DCO** Large US Ethanol company wishes to deploy
- **Purpose Grown Crops** such as camelina and carinata

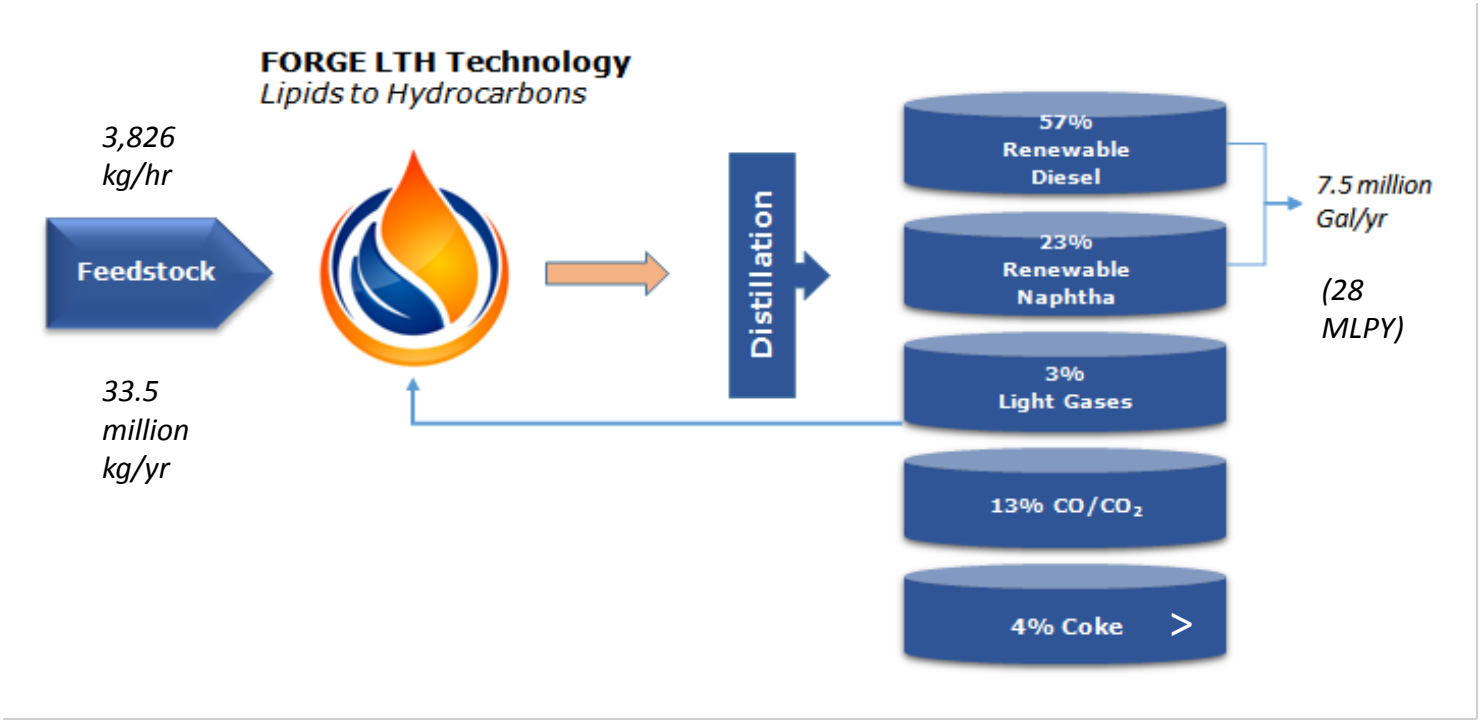
Addressing Demand for Renewable Products

COMPLIANCE is key! - CARBON INTENSITY is crucial

- A sustainable energy strategy is dependent on the development of renewable, alternative fuels that displace the petroleum based products
- Commercialization of the LTH technology has the potential to significantly contribute to the reduction of global greenhouse gas ("**GHG**") emissions as economies reduce dependence on petroleum based fuels
  - The fuels produced by the LTH process **result in GHG emission reductions of greater than 90% using low value traditional fats and oils** compared to petroleum equivalent
- The primary feedstocks used in the LTH process are lower quality rendered fats and oils.

Overview of the LTH Process

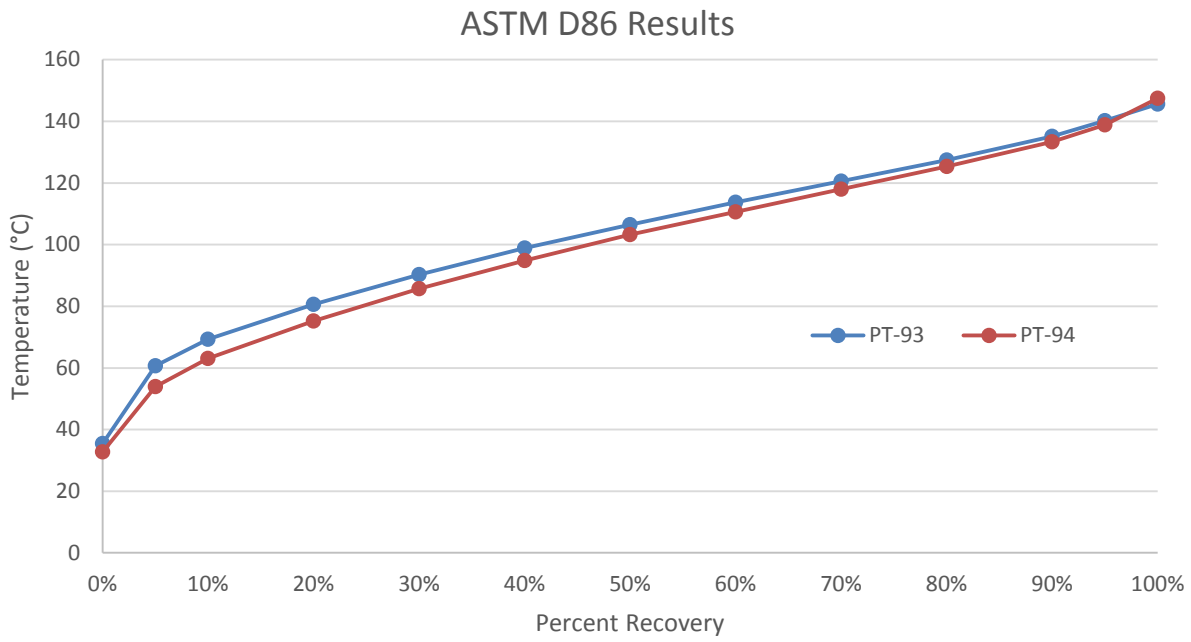
The LTH technology utilizes a robust bio-refining approach to produce a renewable, drop-in fuel that is chemically indistinguishable from petroleum derived fuels



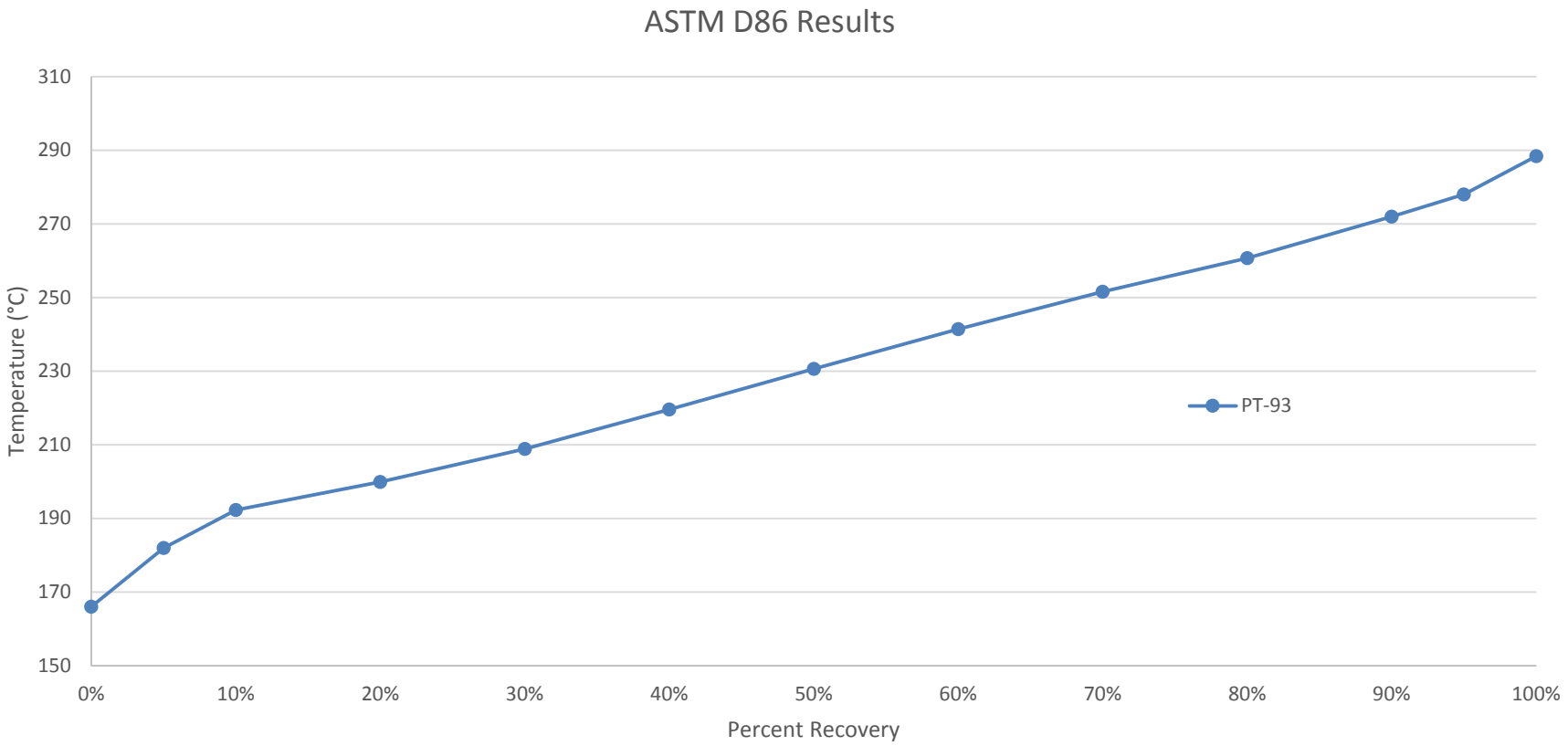
LTH Process

- Currently FORGE technology is optimized to produce renewable diesel and renewable naphtha
- Renewable diesel has been tested to meet ASTM D975 specs
- Naphtha has been tested to ASTM D6615 Jet B specs
- The next step in the FORGE technology development is to add biojet to the product mix.
- FORGE will be entering the Sky's the Limit Challenge with the goal of at the demonstration plant scale proving out the biojet will meet ASTM D7566
- The intent would be to incorporate this improvement into the FORGE plant 2

LTH Naphtha Cut



LTH Renewable Diesel Cut



LTH Technology: 3 Distinct Advantages

FORGE's Lipid-to-Hydrocarbon technology offers an innovative approach in the development of renewable fuels

1

Product Quality - Without Catalysts or Hydrogen

The Company claims to produce a "drop-in" solution that is does not feed further processing and is fungible with petroleum fuels.

2

Cheaper Feestocks, Lower CI

The LTH process can utilize a broad range of 'dirty', high fatty acid, waste feedstocks which are lower cost, lower carbon intensity and have greater societal acceptance than cleaner feedstocks required for some current commercial processes.

3

Simpler, Less Capital Intensive Process

FORGE's LTH process is non-catalytic and doesn't require the use of hydrogen, making it simpler than its competitors. The lower capital intensity enables smaller plants, better matched to the waste oil supply chain to be deployed.

These factors lead to greater margins compared to competitors

FORGE HYDROCARBONS