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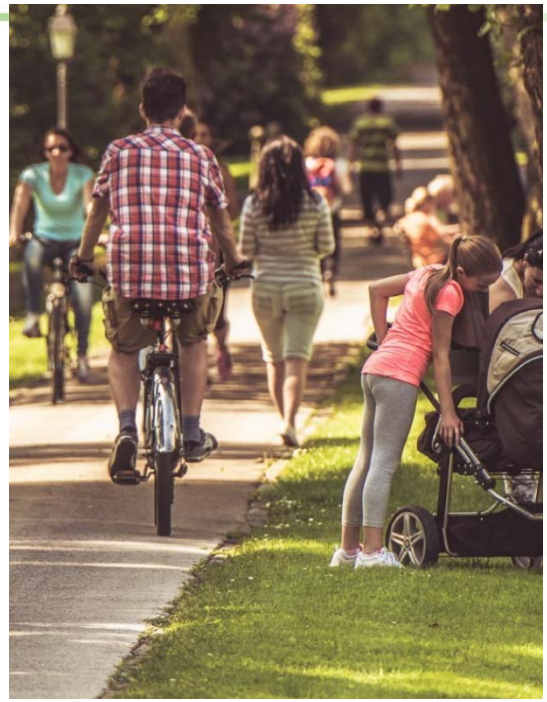
DE SUSTENTABILIDAD
ENERGÉTICA

LanzaTech Alcohol to Jet Technology

Speaker: Prabhakar Nair

Date: September 4 & 5, 2018
Mexico City

Energy can be Carbon Free



Chemicals for Everyday Products need Carbon

Aviation Fuel needs Carbon

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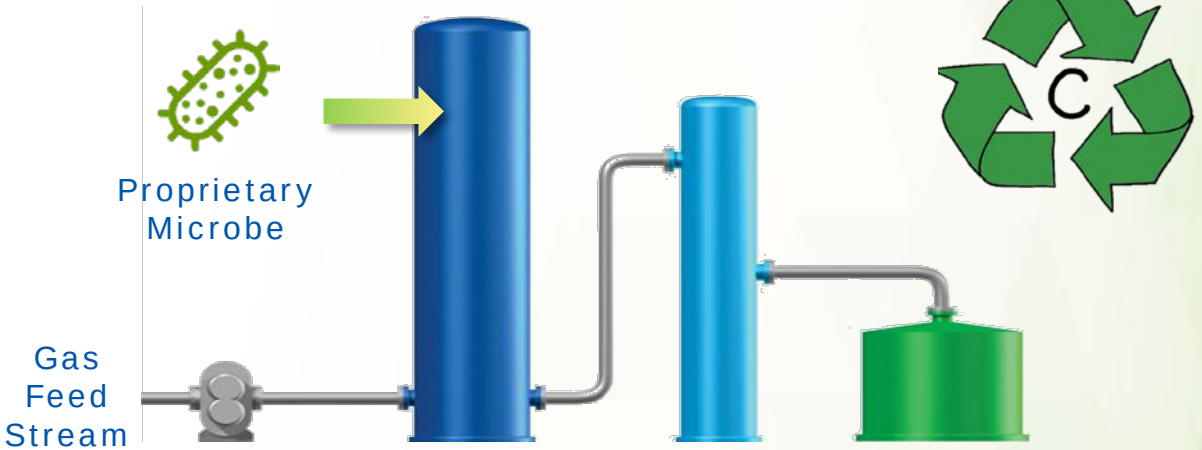
Recycling Carbon

Industrial Off Gas
Biomass, MSW Syngas



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Status Shougang Commercial Plant

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Commercial Projects under Implementation

首钢朗泽
Shougang LanzaTech

China
48k MTA
2018

ArcelorMittal
Steelanol
Fueling a sustainable future

Belgium
62k MTA
2020

SWAYANA

South Africa
52k MTA
2020

इंडियनऑयल
IndianOil

India
34k MTA
2020

Industrial Off Gases

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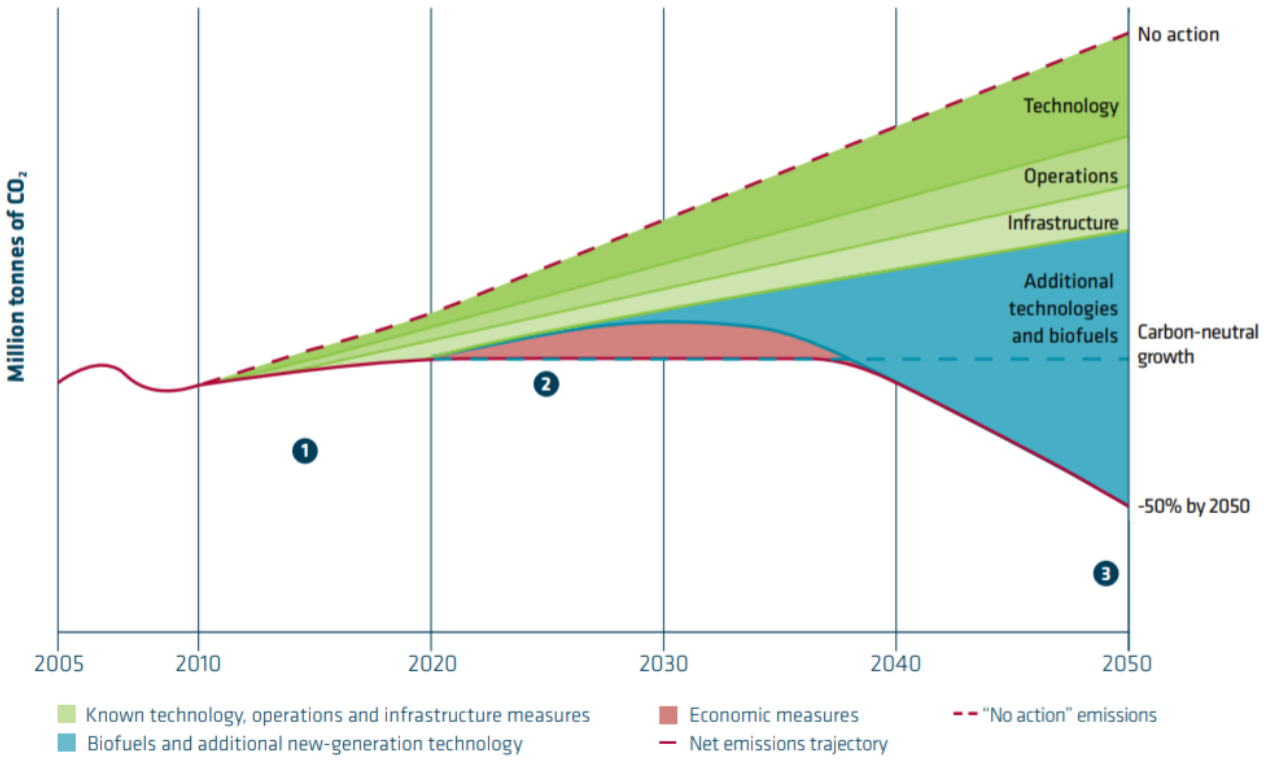
CORSIA Commitments



1_Improve fleet fuel efficiency by 1.5% per year from now until 2020

2_Stabilise net emissions from 2020 through carbon neutral growth

3_By 2050, net aviation carbon emissions will be half of what they were in 2005

(Schematic, indicative diagram only)

Graph source: Reducing Emissions From Aviation Through Carbon Neutral Growth From 2020 (ICAO 2013)

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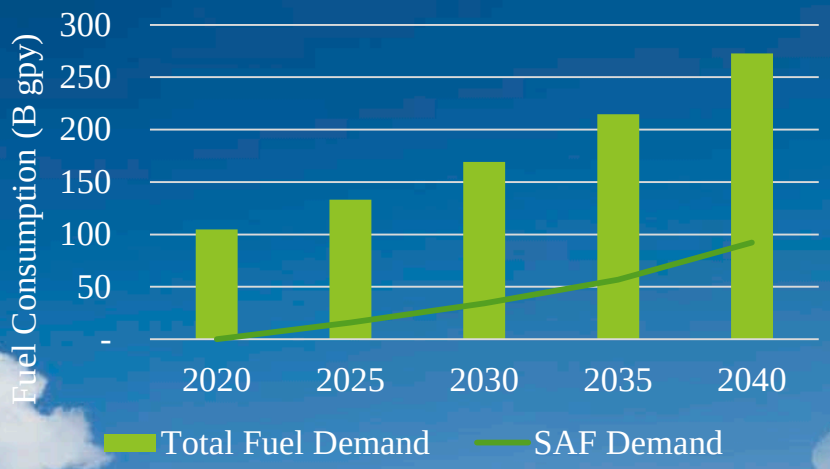
Sustainable Aviation Fuel will Play a Key Role



SAF will need to rise to >30% of total jet fuel consumption by 2040 to meet ICAO commitments

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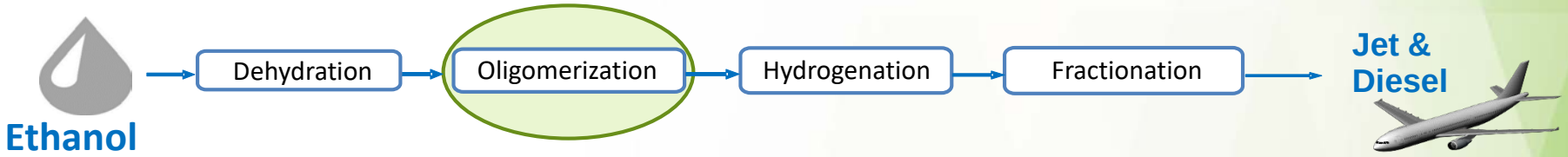
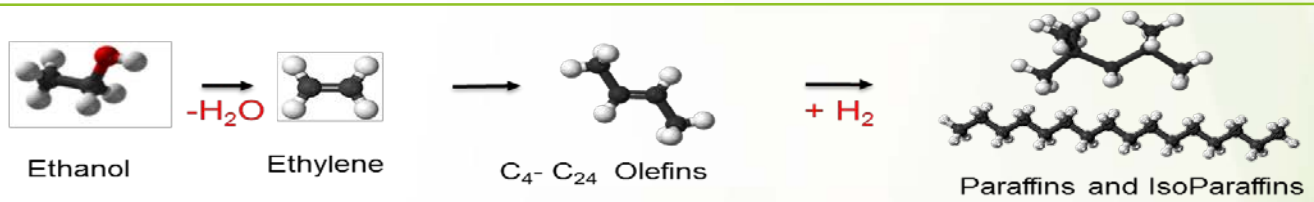
From Waste to Wing





Jet range hydrocarbons (C8-C16) selectively built from smaller molecules

首钢朗泽 Shougang LanzaTech

U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

BOEING

virgin atlantic

HSBC

Pacific Northwest NATIONAL LABORATORY

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LanzaTech Jet Production Campaign

LanzaTech Produced…
✓4000 gallons Jet
✓600 gallons Diesel

- **Demonstrated feedstock flexibility**
  - 1,500 gal from waste gas ethanol (Lanzanol)
  - 2,500 gal from Grain Ethanol
- **Waste gas ethanol (Lanzanol) produced in an RSB-certified demonstration facility**
  - Shougang-LanzaTech 100,000 gal/yr China demonstration plant

Increased Run Time and Production Rate → **Improved Product Yield** → **Reduced Operating Cost** → **Lower Cost Commercial Product**

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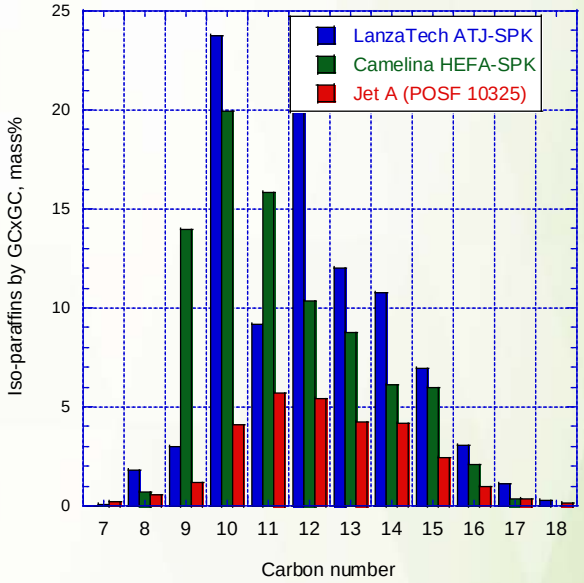
LanzaTech Jet Property Highlights

Fuel Property	Jet A Spec	LanzaTech ATJ-SPK	50/50% v with Jet A
Freeze Point, °C	-40 max	-61	-54
Energy Density, MJ/kg	42.8 min	44.4	43.8
Thermal Stability	Baseline	Excellent	Excellent
Viscosity @ -40 °C mm^2/sec	12 max	7.0	9.3
Hydrogen %	13.4 min	15.1	14.5
Aromatics %	8 min, 25 max	Nil	8.8
Sulfur, total mass %	0.30 max	<0.001	0.02

Meets or Exceeds Critical Jet Fuel Specifications

Neat fuel primarily isoparaffins with <0.2% aromatics



Carbon number range similar to conventional jet fuel and other SPK's

On April 1, 2018 ASTM Intl. Revised D7566 ATJ SPK Annex A5

- **Added Ethanol as a feedstock**
- **Increased final blend ratio to max 50 %**

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Pacific Northwest NATIONAL LABORATORY

Global Ethanol Feedstock Sources

Agricultural Waste
~600B gpy

Municipal Solid Waste:
~26B gpy

Ferro-Alloy Offgas:
~1B gpy

Ethanol

Refinery Offgas:
~3B gpy

Steel Mill Offgas:
~50B gpy

Ethanol Provides Path to Sustainable Aviation Fuel from Abundant Wastes and Residues

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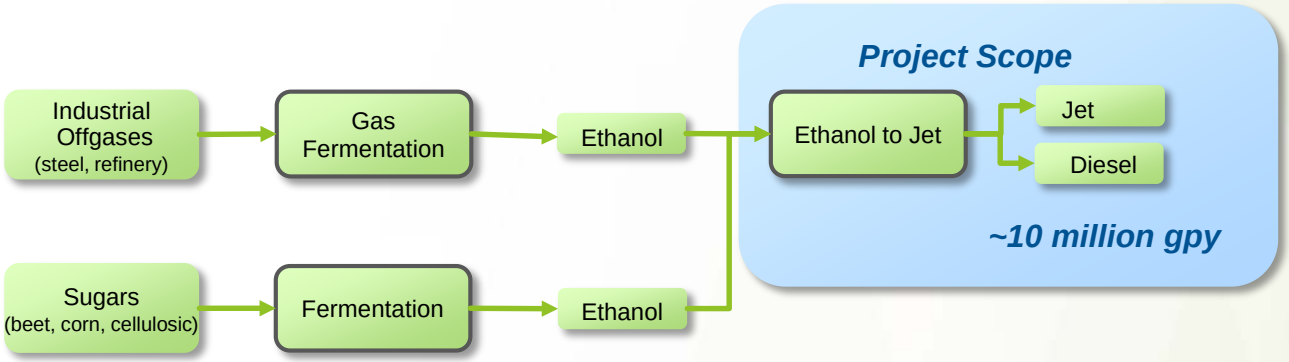
US DOE Pre-Commercial Project



Project Objectives:

- **Demonstrate the ability to convert ethanol from multiple feedstocks into sustainable aviation fuel**
- **Develop process and operational parameters for commercial ethanol-to-jet units**
- **Produce commercial quantities of jet and diesel fuel**

Produce commercial quantities of sustainable aviation fuel for offtake in Q1 2020

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UK Department for Transport Feasibility Study

- Commercial-scale ATJ production from waste-based ethanol
- Includes ethanol from steel mill waste gas fermentation
- Site selection and project planning underway

Stage 1 Outcome:
Financeable Commercial-Scale ATJ Project in UK

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Direction of Sustainable Aviation Fuel

- Feedstock cost, availability, and sustainability are key
- Need abundant, low cost feedstocks that do not compete with food
- Wastes and residues are a major resource for SAF
- Ethanol-based ATJ offers an opportunity to produce jet with > 70% GHG reductions from sustainable crops, wastes and residues appropriate for each region
- Competitive SAF economics will come from expanding feedstock sources, production capacity and market demand

All sustainable solutions are needed to meet growing global demand

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THANK YOU
FOR YOUR ATTENTION