
ICAO Symposium on
Non-CO_2 Aviation
Emissions
16 —— 18 September 2024
Montréal, Canada

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Speaker

Session 3: Mitigating Non-CO2 Aviation Emissions – What is possible

Part III - Sustainable Aviation Fuels (SAF), Lower Carbon Aviation Fuels (LCAF), and Cleaner Energy

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CleanJoule is a mission driven, technology company with over a decade of innovation

MISSION

Pave the way to net zero aviation through 100% drop-in and low cost SAF

BUSINESS

CleanJoule develops technology to produce next generation sustainable aviation fuel

We are making SAF affordable and available for everyone, everywhere

TIMELINE

2009

CleanJoule began through a series of contracts with the Department of Defense and Department of Energy to pioneer an advanced SAF production pathway

2019

After a decade of research and development, CleanJoule optimizes a novel technology, transforming biomass into SAF with high carbon efficiency

2023

CleanJoule secured ~$52MM from an international consortium of investors to scale and build a demonstration plant

2024

CleanJoule's CycloSAF product is accepted into the ASTM committee's SAF qualification process

ASTM INTERNATIONAL

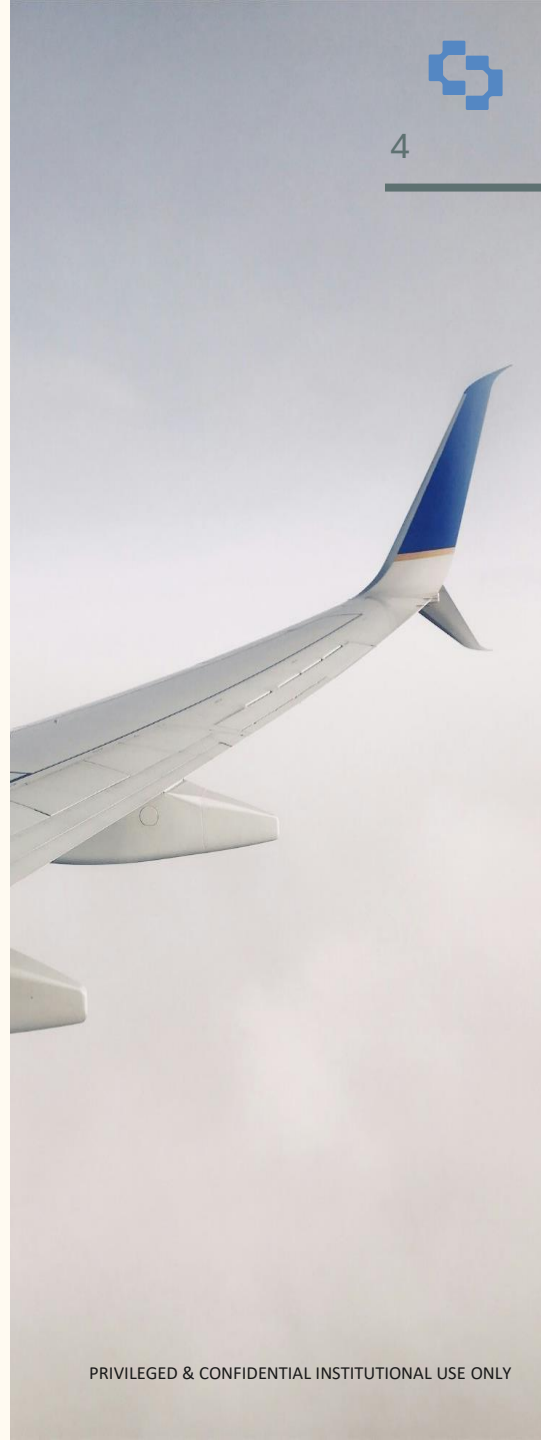
CleanJoule's strategic investors

PRIVATE EQUITY AND SWF

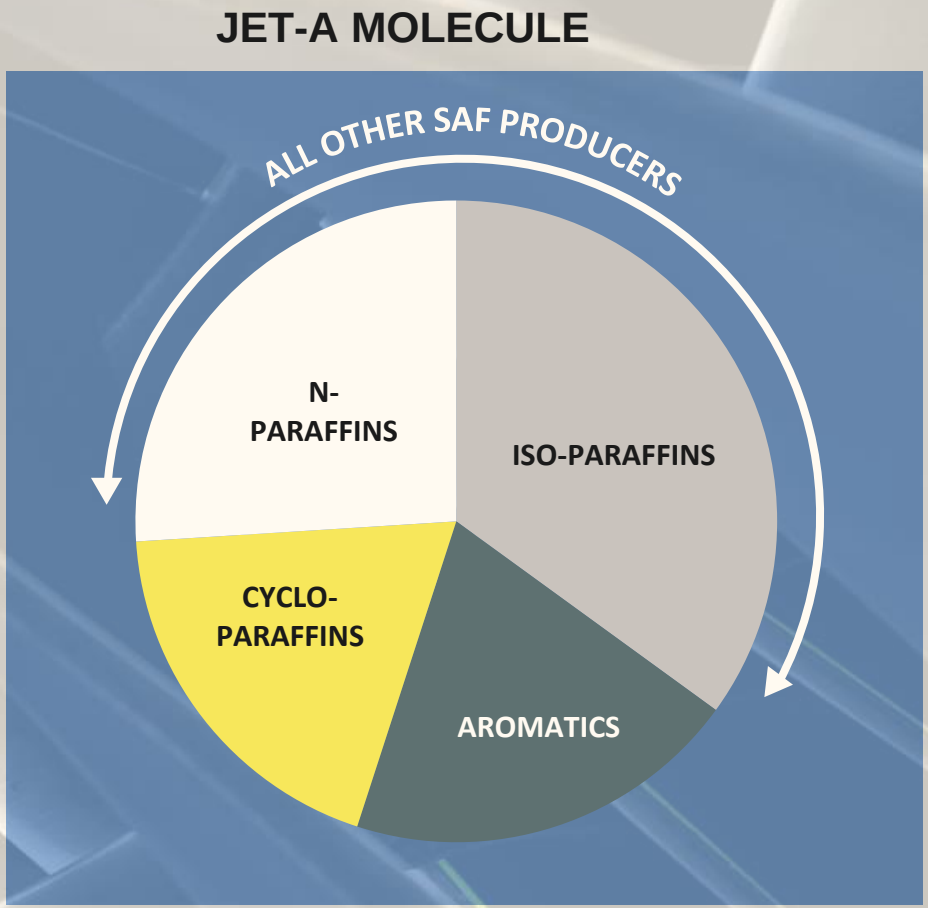
- Indigo Partners is a leading investor in five low-cost airline, providing access to a global network of aviation and OEM partners
- GenZero is the cleantech investment entity of Temasek based in Southeast Asia
- Cleanhill Partners is a growth equity investor in energy decarbonization

AIRLINES

- Frontier Airlines, Volaris, and Wizz Air are low-cost airlines operating out of the US, Mexico, and Europe that have fleets of 148, 136, and 218 planes, respectively
- In total, these airlines have signed 90 MM gallons of offtake with CleanJoule



Understanding Jet-A and the role SAF plays in replacing it



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An experimental demonstration showed that reducing aromatics by 50% results in more than a 50% reduction in contrails

DC8 chasing a contrail from the A320 burning a SAF blend above Germany, 24 January 2018

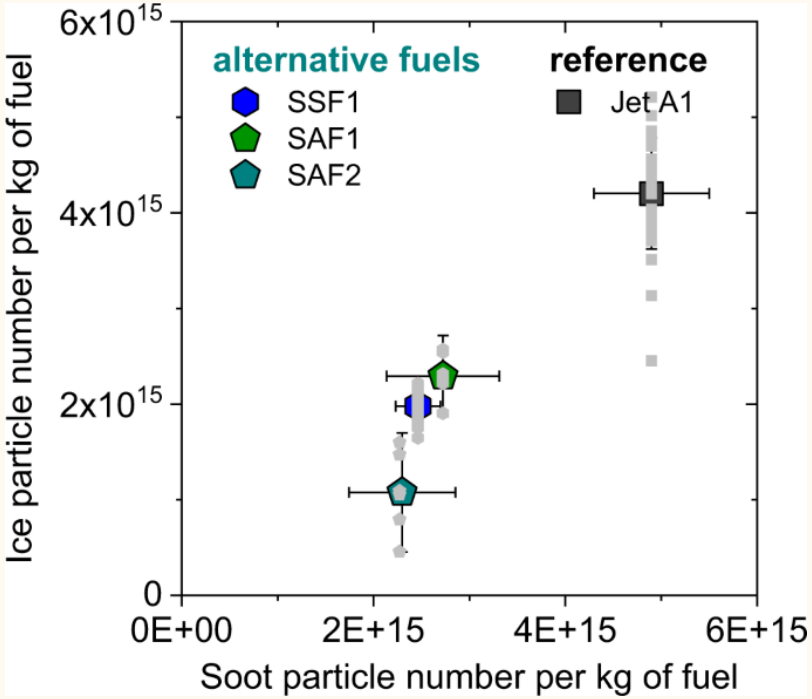
Results

Burning low aromatic sustainable aviation fuel can result in

- 50 to 70% reduction in soot and ice number concentrations
- Reduced secondary GHG impact

Takeaway

- Reducing aromatics makes a meaningful impact in reducing aviation's climate impact beyond CO_2 emissions
- CycloSAF allows for 100% SAF without aromatics



SSF1: 11% aromatics (Synthetic petroleum blend)
SAF1: 8.5% Aromatics (Fischer-Tropsch /petroleum blend)
SAF2: 9.5% aromatics (HEFA /petroleum blend)
Jet A1: ~18.8% aromatics

https://www.nature.com/articles/s43247-021-00174-y

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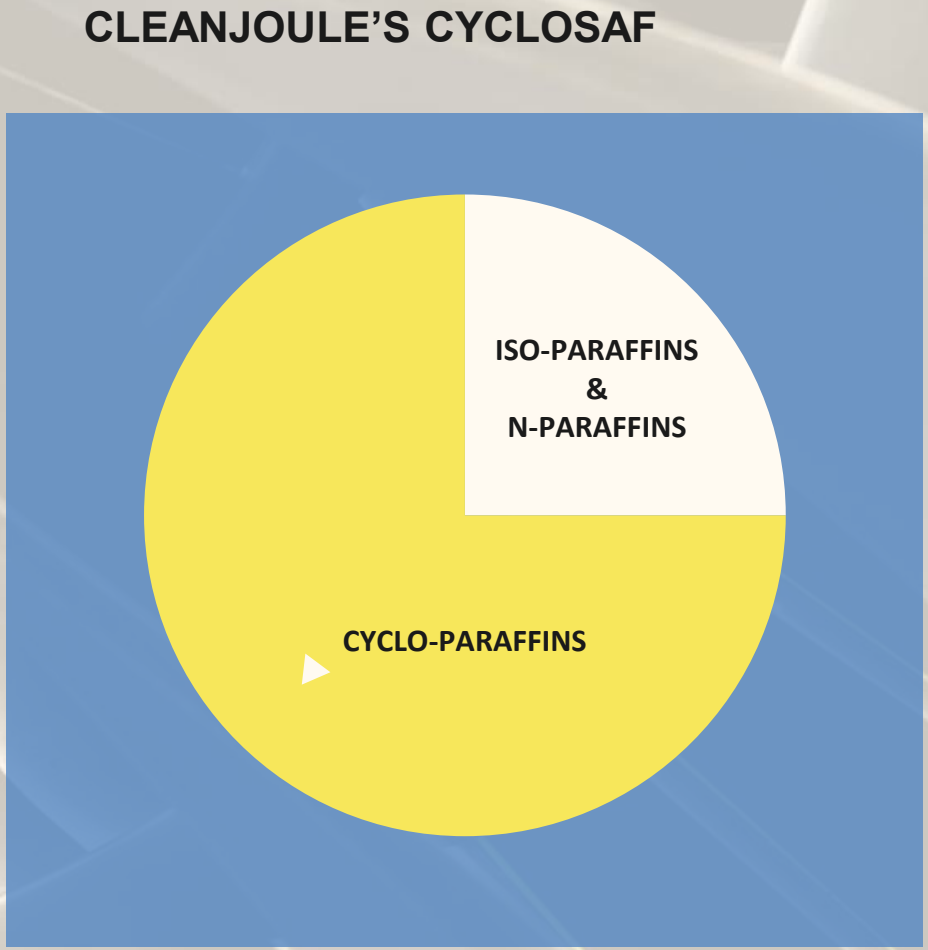

Comparing the performance of Jet-A and SAF

TEST OVERVIEW

- In 2024, The Air Force Research Laboratory (AFRL) in partnership with University of Dayton Research Institute (UDRI) performed a combustor rig test with CleanJoule's CycloSAF

CYCLOSAF TEST RESULTS

- **Reduces particulate matter (PM) emissions by 75-86%** due to the absence of aromatics
  - Reduction in engine maintenance frequency
  - Reduced contrails formation
- 100% CycloSAF (unblended with Jet-A) can produce **similar combustion performance as average jet fuel**, with no impact on operation
- Currently, ASTM only allows SAF from existing pathways (ATJ, HEFA, PtL, FT) to be blended to a **max of 50%** to meet the standards of average jet fuel

PROPERTY	100% CYCLOSAF	10:90 CYCLOSAF: JET-A	100% SAF Blend	ASTM D7566
Density (g/ml)	0.824	0.808	0.780	> 0.775
η(-20 °c) [mm^2s^{-1}]	4.10	4.10	5.03	< 8.0
η(-40 °c) [mm^2s^{-1}]	7.70	8.03	10.54	< 12
NHOC (mj kg^{-1})	43.5	43.17	43.76	> 42.8
Flash point	53	49	51	> 38
Corrosion (no.)	1B	1A	1A	1
Smoke point (mm)	39.3	22.6	49.4	> 25
Conductivity (ps/m)	<1	255	STADIS	50-600 (Jet-A)
Simulated dist. (T50-t10)	179	34.3	28.5	> 15
Simulated dist. (T90-t10)	179	102.6	104	> 40
Exist. Gum (mg/100 ml)	<1	1	4	< 7
Lubricity (mm)	0.60	0.590	0.734	< 0.85
Thermal stability	Code: 1; pressure drop (0 mmHg); deposits (16 nm)	Code: 1; pressure drop (13 mmHg); deposits (10.8 nm)	Code: 1; pressure drop (0 mmHg); deposits (7.050 nm)	Code (<3); pressure drop (<25 mmHg); deposits (<85 nm)
Acidity (mg koh/g)	0.00	0.013	0.001	v
Derived cetane no.	21	43	44.1	> 30

(1) Both tests completed by US Navy at China Lake Naval Air Station and the Southwest Research Institute in San Antonio

Thank You

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