FLYING GREEN

SUSTAINABLE AVIATION FUELS
OFFSETING THE ENVIRONMENTAL IMPACT OF A FAST GROWING INDUSTRY

Prepared by Stéphane Thion
**AIR PASSENGER IS SKYROCKETING**

**14 BILLION NEW PASSENGERS BETWEEN 2017 AND 2040**

- **North America**: 3.36bn (2017) - 1.86bn (2040)
- **Europe**: 4.27bn (2017) - 2.22bn (2040)
- **Asia-Pacific**: 10.29bn (2017) - 3.01bn (2040)
- **Latin America & Caribbean**: 2.04bn (2017) - 0.61bn (2040)
- **Africa**: 0.39bn (2017) - 0.19bn (2040)
- **Middle East**: 1.92bn (2017) - 0.39bn (2040)

**2017 | 8.3 Billion** | **2040 | 22.3 Billion**

Air transport is growing at a 6% per year in numbers of passengers

Source: Kilde, ACI Europe
AVIATION IS A GROWING SOURCE OF CO₂ EMISSIONS
AVERAGING MORE THAN 4% ANNUAL GROWTH

Aviation represents 2.5% of global CO₂ emissions!

Source: IATA, Industry Statistics, Factsheets, December 2018
INTERNATIONAL AVIATION CLIMATE TARGET
AMBITION GOALS TO CUT CO₂ EMISSIONS 50% BY 2050 (VS 2005)

Biofuels are a pillar towards a sustainable aviation

(1) Carbon Offsetting and Reduction Scheme for International Aviation

Source: ICAO’s Air Transport Action Group
CARBON NEUTRAL GROWTH 2020
ESTIMATED QUANTITIES OF CO\textsubscript{2} TO OFFSET (IN MM TONS)

Up to 800MM tons of CO\textsubscript{2} to offset in 2040 (~2016 total global emissions)

Source: ICAO’s Committee on Aviation Environmental Protection (CAEP) analysis, 2016
SAF PLACE IN A DECARBONIZED AVIATION INDUSTRY
FROM SMALL DEMONSTRATION QUANTITIES (>160,000 COMMERCIAL FLIGHTS SINCE 2008) TO AROUND 100MM TONS BY 2040!

2018 SAF < 0.1% total aviation fuel consumption

<table>
<thead>
<tr>
<th>Year</th>
<th>CO₂ to offset</th>
<th>Fuel share (ICAO)</th>
<th>Fossil fuel equivalent (1)</th>
<th>SAF equivalent (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2018 (Actual)</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>12</td>
</tr>
<tr>
<td>2025</td>
<td>160,000</td>
<td>10%</td>
<td>5,000</td>
<td>7,000</td>
</tr>
<tr>
<td>2030</td>
<td>330,000</td>
<td>15%</td>
<td>16,000</td>
<td>22,000</td>
</tr>
<tr>
<td>2035</td>
<td>520,000</td>
<td>20%</td>
<td>33,000</td>
<td>46,000</td>
</tr>
<tr>
<td>2040</td>
<td>700,000</td>
<td>30%</td>
<td>66,000</td>
<td>92,000</td>
</tr>
</tbody>
</table>

Figures in ‘000 tons

How to deliver such high levels of SAF production?

(1) 3.17g CO₂ emission per g of fossil fuel  (2) Considering SAF provides a 60% reduction in GHG emissions
TECHNOLOGY DEVELOPMENT IS ESSENTIAL
ASTM APPROVAL PROCESS IS STRICT AND COSTLY BUT CRITICAL TO INCREASE SAF AVAILABILITY

<table>
<thead>
<tr>
<th>Approved Pathways</th>
<th>FT-SPK (A)</th>
<th>HEFA</th>
<th>SIP</th>
<th>AtJ(^{(1)})</th>
<th>Co-processing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Synthesized Paraffinic Kerosene</td>
<td>Hydroprocessed Esters &amp; Fatty Acids</td>
<td>Synthesized Iso-Paraffins</td>
<td>Alcohol To Jet</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Year of approval</th>
<th>Time until approval</th>
<th>Feedstocks</th>
<th>Blend limit</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>2009 (2015)</td>
<td>3 years</td>
<td>Biomass, MSW (Coal, Gas)</td>
<td>50%</td>
<td>Demo</td>
</tr>
<tr>
<td>2011</td>
<td>3 years</td>
<td>FOGs</td>
<td>50%</td>
<td>Commercial</td>
</tr>
<tr>
<td>2014</td>
<td>3 years</td>
<td>Sugars</td>
<td>10%</td>
<td>Commercial</td>
</tr>
<tr>
<td>2016 (2018)</td>
<td>5½ years</td>
<td>Starches, sugars, cellul. biomass</td>
<td>30-50%</td>
<td>Pilot/Demo</td>
</tr>
<tr>
<td>2018</td>
<td></td>
<td>FOGs(^{(2)})</td>
<td>5%</td>
<td></td>
</tr>
</tbody>
</table>

7 approved pathways within the last 10 years (3+ years until approval)
8 pathways actively pursuing certification (1 phase 2, 5 phase 1, 2 inactive)

Accelerating new pathways approvals is key to developing a secure and sustainable aviation industry

\(^{(1)}\) From Isobutanol (Gevo) or Ethanol (Lanzatech)  \(^{(2)}\) Work toward adding FT derived biocrude feedstocks
PRODUCTION EFFICIENCY AND OUTPUT
DIESEL VS. JET

Commercially available processes chemically predisposed to favor diesel

Source: The cost of supporting alternative jet fuels in the EU, International Council on Clean Transportation, March 2019
SAF COST RELATIVE TO CONVENTIONAL
AT LEAST TWICE THE PRICE OF FOSSIL JET PRICE

Impossible today for SAF to compete in a market without strong policy support

Source: The cost of supporting alternative jet fuels in the EU, International Council on Clean Transportation, March 2019
POLICIES ARE CRITICAL TO STIMULATE SAF DEMAND
WITHOUT SUPPORTIVE POLICIES SAF SCALE UP IS UNLIKELY

**Today**

- **United States**
  - RFS2 – SAF generate RINs

- **European Union**
  - RED – Voluntary
  - RED II – x 1.2 (but no mandate)

- **Norway**
  - Mandate – 1% in 2019, 30% in 2030

- **Indonesia**
  - Mandate – 2% (not enforced)

**Tomorrow**

- **ICAO**
  - Carbon compensation (CORSIA)

- **Canada**
  - Multiplier considered

- **Brazil**
  - Tax exemptions on internal flights

- **China**
  - Goal of 30% by 2030

- **Spain**
  - Mandate proposition 2%

- **Sweden**
  - Mandate proposition on internal flights

- **France**
  - Mandate proposition 2% by 2025

Need for clear & **stable** long term policies!
THE FRENCH EXAMPLE
A MANDATE BY 2020?

Green Deal
Evaluate (1) feedstocks/technologies, (2) logistic, and (3) support mechanisms

Possible roadmap
Minister of transport official announced 2% SAF by 2025

<table>
<thead>
<tr>
<th>Année</th>
<th>Volume Kérosène (Scénario AMS de la SNBC)</th>
<th>Cible à atteindre, % d'incorporation en volume</th>
<th>Equivalence en tonnage de biocarburants</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>7 800 000 tonnes</td>
<td>0,5%</td>
<td>40 000 tonnes</td>
</tr>
<tr>
<td>2025</td>
<td>8 400 000 tonnes</td>
<td>2,0%</td>
<td>170 000 tonnes</td>
</tr>
<tr>
<td>2030</td>
<td>9 000 000 tonnes</td>
<td>5,0%</td>
<td>450 000 tonnes</td>
</tr>
</tbody>
</table>

450,000 tons of SAF in France by 2030?
THE SUSTAINABILITY EFFECTS
A GROWING SOCIETAL AND POLITICAL PRESSURE

Growing societal and political pressure
- Circular economy
- Reduce pressure on resources
- Deforestation
- Compliance with regulations (RED, CORSIA)

Feedstock access and certification
- Plant and animal fats, oils and greases
- Lignocellulosic waste and residues
- Traceability, ILUC

Supply chain transparency
- Certified GHG benefits
SUMMARY
PATH TO SAF DEPLOYMENT

Technology development
Accelerate new pathways approvals

Economics
Reduce production costs

Policies
Set stable long term policy measures

Sustainability
Access feedstocks while meeting societal and political expectations

READY FOR TAKE OFF!
THANKS FOR YOUR ATTENTION