Sustainable aviation fuels: Where we are and where are we headed

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Trends in future of Aviation

Demand in February from 7 Million barrel/b => 6 200 000

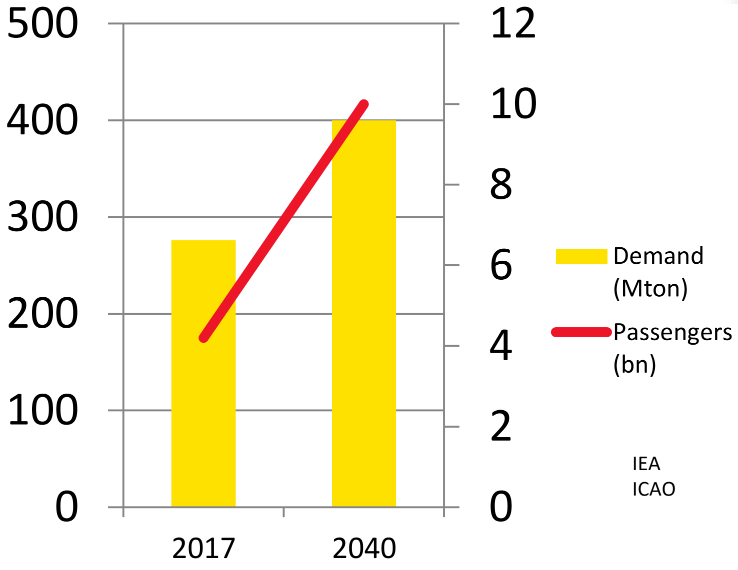
April forecast in Nordics 80% demand drop…

Aviation demand is ***growing*** *rapidly*

Aviation accounts for around 15% of global oil demand growth up to 2030 in the IEA's New Policies Scenario, a similar amount to the growth from passenger vehicles. Such a rise means that aviation will account for 3.5% of global energy related CO2 emissions by 2030, up from just over 2.5% today, despite ongoing improvements in aviation efficiency.

CO2 emissions from aviation continue to rise, and accounted for around 2.5% of global energy-related CO2 emissions in 2018.

The energy efficiency is expected to improve slower than transportation need. Thus, continuing with the current path the fuel demand is estimated to grow 200% during the next 30 years[2)].



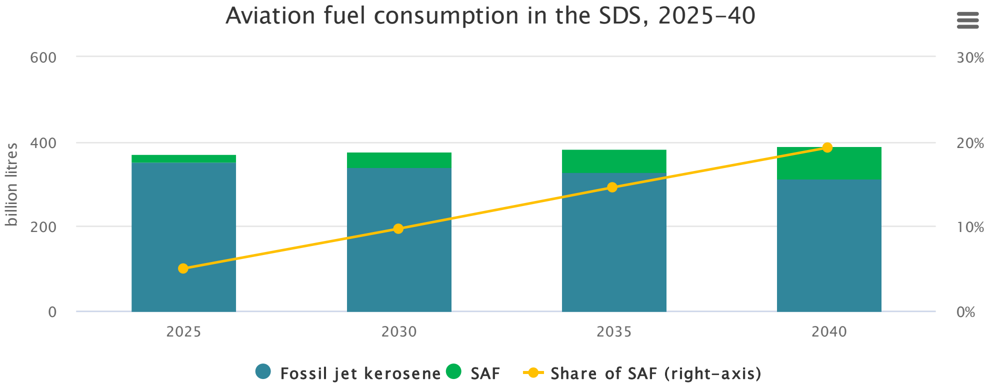
Global JET demand & price assumptions

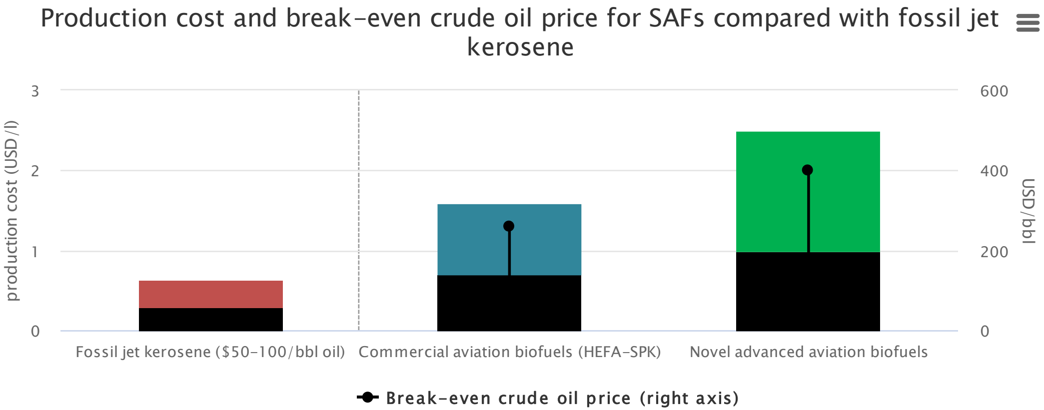
"Biojet is substantially more expensive than fossil alternative"

IEA Sustainable development scenario requires 20% uptake of SAF by 2040

SAF prices are multiple times higher than fossil alternative

Could electric flights challenge this?





Notes: Novel advanced aviation biofuels refers to Fermented Sugars-to-Synthetic Isoparaffin (HFS-SIP), Alcohol-to-Jet (ATJ) and Fischer-Tropsch pathways. In reality these production pathways have different fuel production cost ranges

Challenges to be solved in future of Sustainable Aviation Fuels

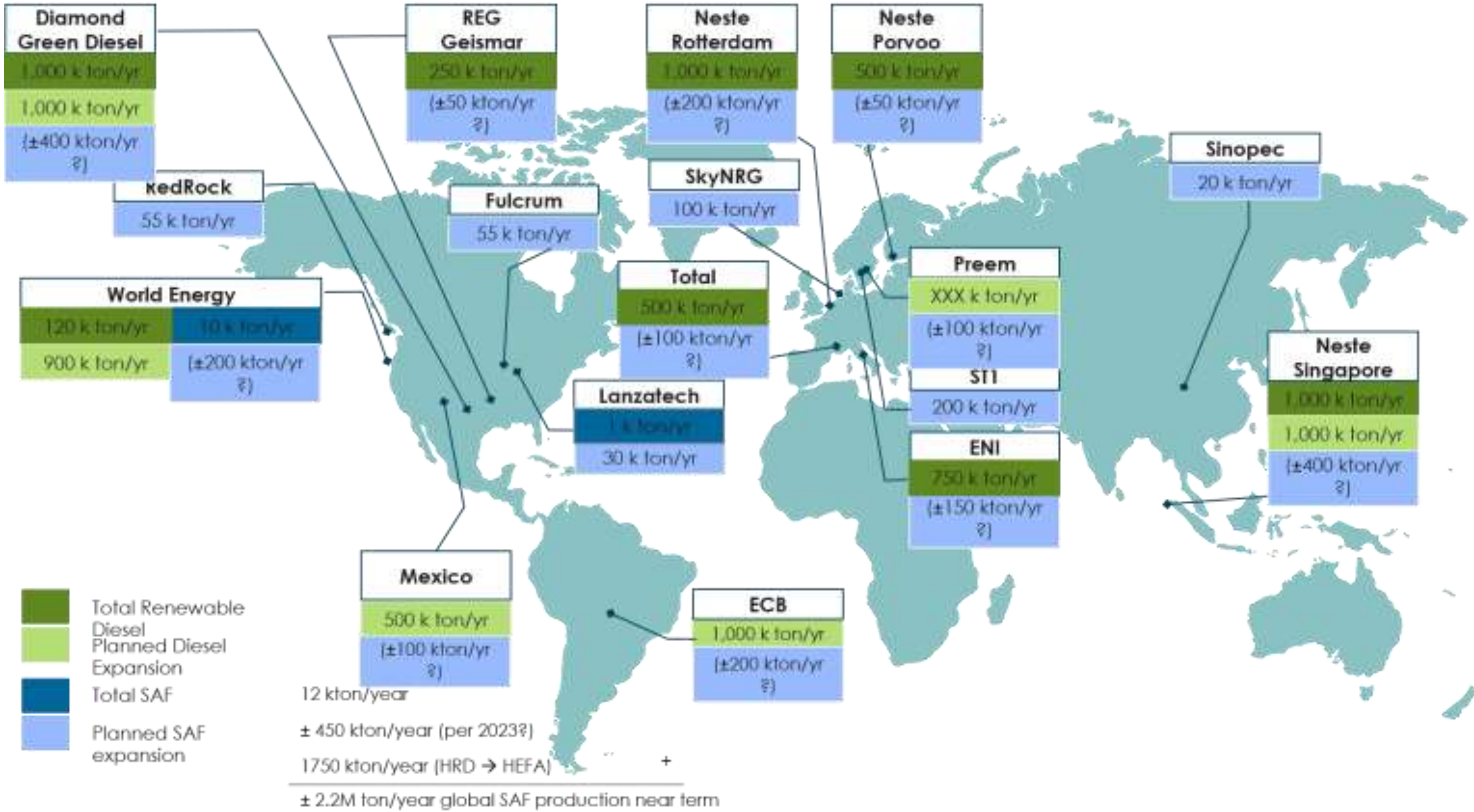
"Jet A-1 fuel has the highest growth rate out of all products that are produced in oil refineries. This creates a challenge in decarbonizing distillation curve"

CHALLENGE 1: PRODUCTION CAPACITY

CHALLENGE 2: FEEDSTOCK SECURITY AND SUSTAINABILITY

CHALLENGE 3: TECHNOLOGY DEVELOPMENT

1. Production capacity: small share of existing HVO suitable for biojet



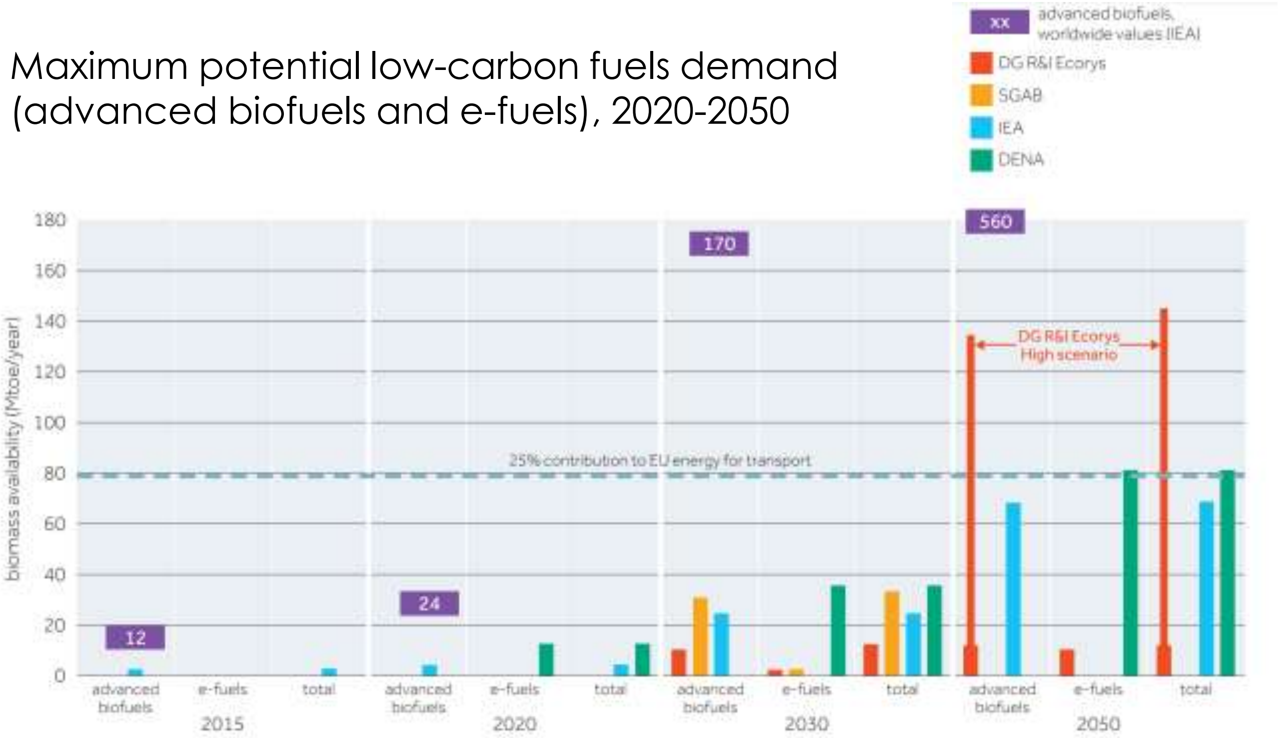
2. Feedstock Security: Uncertainties in availability and sustainability

1. Biomass availability has lot of uncertainties depending on scenario

2. Sustainability criteria is putting limits to utilization of technologically easiest feedstocks

3. CO_2 to be used as a feedstock for e-Jet

Maximum potential low-carbon fuels demand (advanced biofuels and e-fuels), 2020-2050



3. Technological development: acceptability and costs must come down

Technology	Code	Feedstock	Max blend	Technology Providers*
Fischer-Tropsch	FT	Biomass/MSW/ Nat Gas	50%	Fulcrum, Velocys, Shell,
Hydro processed Ester and Fatty Acids	HEFA	Oils, Fats & Greases	50%	UOP, Neste, Eni, World Energy, SG preston
Synthesized iso-parraffins	SIP	Sugars	10%	Amyris
FT Synthesized Paraffinic Kerosene plus aromatics	SPK/A	Biomass, MSW, Coal	50%	Sasol
Isobutanol to Jet	ATJ-SPK	Sugars, Biomass, MSW	30%	Gevo, Lanzatech
catalytic hydrothermolysis jet fuel (CHJ)	CHJ	waste oils or energy oils	50%	Applied Research Associates (ARA)

ASTM, 2020

* Non-exhaustive list of

SAF Characteristics

Currently only **5 ASTM approved** methods of production

Maximum **50 % blending** with conventional jet fuel

Higher **fuel efficiency** up to 3%

Mandates are (maybe) coming in Europe… Will there be enough fuels?

The Netherlands

Government studying SAF supply obligations with a **14% target in 2030**. First SAF plant (SkyNRG) in 2022

Germany

Aviation Initiative for Renewable Energy in Germany (AIREG) goals: at least one large-scale refinery and a 10% blend by 2025

France

SAF roadmap to reach a SAF supply of **2.5% in 2025 and 5% in 2030**

Spain

Climate Change Law: **2% SAF supply objective in 2025**

Portugal

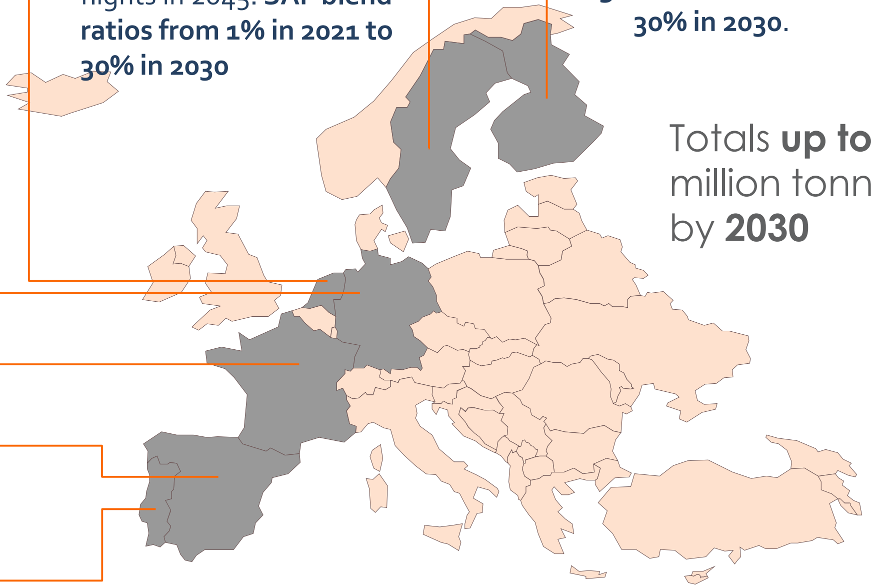
Roadmap for Carbon Neutrality (RNC2050): integrated approach to transport decarbonisation including aviation

Sweden

'Fossil Free Sweden'. Fossil free domestic flights in 2030 and all departing flights in 2045. **SAF blend ratios from 1% in 2021 to 30% in 2030**

Finland

A carbon neutral country by 2035: **Increasing SAF obligation to reach 30% in 2030**.



Totals **up to 3,5** million tonnes by **2030**

Source: SENASA