Energy transition of air traffic - Lentoliikenteen energiasiirtymä

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Why is the energy transition needed in aviation sector?

To mitigate climate change

The world needs a rapid transformation to limit global warming to 1.5° C. This translates to halving global GHG emissions by 2030 and redefining our economy to meet net zero by 2050.

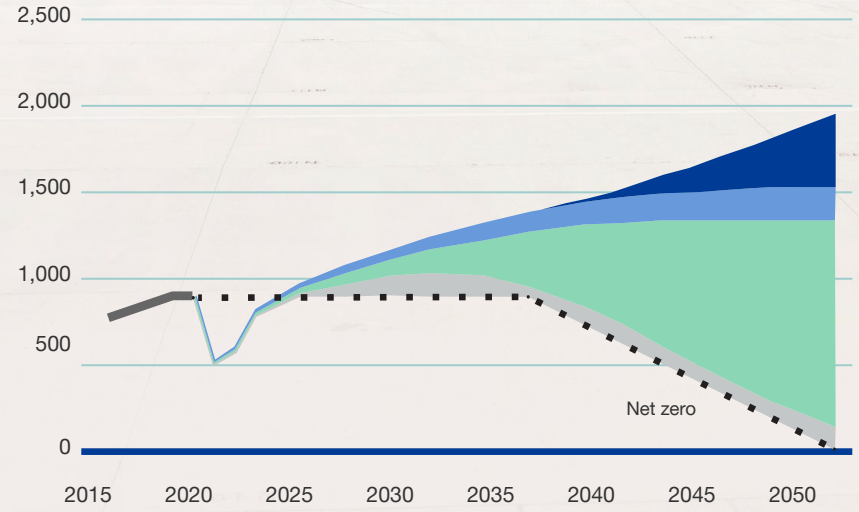
To decarbonize aviation

Aviation accounts for 2-3 % of global GHG / CO_2 emissions.

The role of sustainable aviation fuels (SAF)

Aviation needs growing volumes of sustainable aviation fuels to cut emissions

Aviation CO_2 emissions trajectory and reductions by measure (Mt CO_2e)



To reach net-zero in 2050, the needed SAF contribution to emissions reduction is around 65 %

- Technology (incl. Electric and hybrid aircraft)
- Operations and infrastructure
- Sustainable aviation fuel
- Offsets (or other carbon mitigation measures)

Aviation continues to rely heavily on liquid jet fuel, even with efficiency improvements and emergence of (short-haul) electric planes in the future.

Sustainable Aviation Fuels will be the most important tool in the aviation sector's transition towards net zero.

Source: ATAG Waypoint 2050

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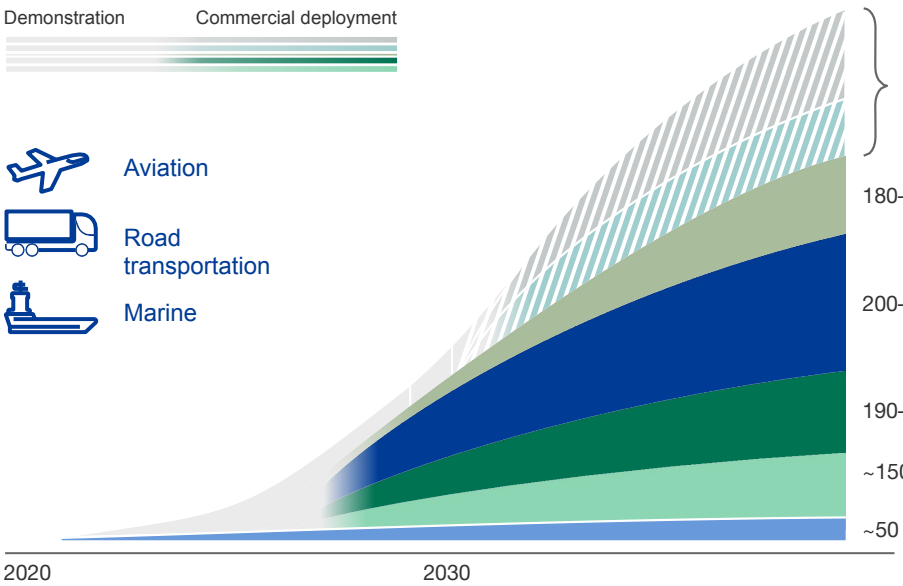
The technical development of Sustainable Aviation Fuels

Unlocking new raw material pools with innovation to accelerate emission reductions in transportation

Global raw material potential for renewable fuels (Mtoe)



Long-term fuel potential (Mtoe)

Significant potential for fuel production in the long term

Power-to-liquids	180–275
Algae	
Cellulosic energy crops	
Lignocellulosic residues (agriculture; forestry)	200–400
Municipal solid waste*	190–250
Novel vegetable oils (cover crops; degraded land)	~150
Waste and residue fats and oils	~50

Renewable raw materials hold significant potential to accelerate the reduction of CO_2 emissions, in particular in the transportation sector.

Regulators hold the key to enable a broad renewable raw material pool to unlock the full emission reduction potential in transport and beyond.

Source: Neste analysis based on WEF Clean Skies for Tomorrow and other sources. Biomass potential converted to fuel potential, using around 85% conversion efficiency (weight-based) for fats and oils and novel vegetable oils; around 25% efficiency for lignocellulosic biomass and municipal solid waste.
*80% organic waste, with 20% non-reusable, non-separable plastic waste

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There are currently seven ASTM approved pathways to produce synthetic blending components from alternative sources

ASTM D7566 Standard Specification for Aviation Turbine Fuel Containing Synthesized Hydrocarbons

2009 | 2011 | 2014 | 2015 | 2016 | 2018 | 2020

These components have to be blended with conventional jet fuel

Annex A1	Annex A2	Annex A3	Annex A4	Annex A5	Annex A5	Annex A6	Annex A7
FT-SPK Fischer Tropsch	HEFA-SPK Hydroprocessed esters and fatty acids	SIP Synthesized iso-paraffins	FT-SPK/A Fischer Tropsch with aromatics	ATJ-SPK Alcohol-to-Jet (Iso-butanol)	ATJ-SPK Alcohol-to-Jet (ethanol)	CHJ Catalytic hydrothermolysis jet	HC- HEFA SPK hydroprocessed hydrocarbons, esters and fatty acids

Source: ASTM, CAAFI

SPK = synthesized paraffinic kerosene

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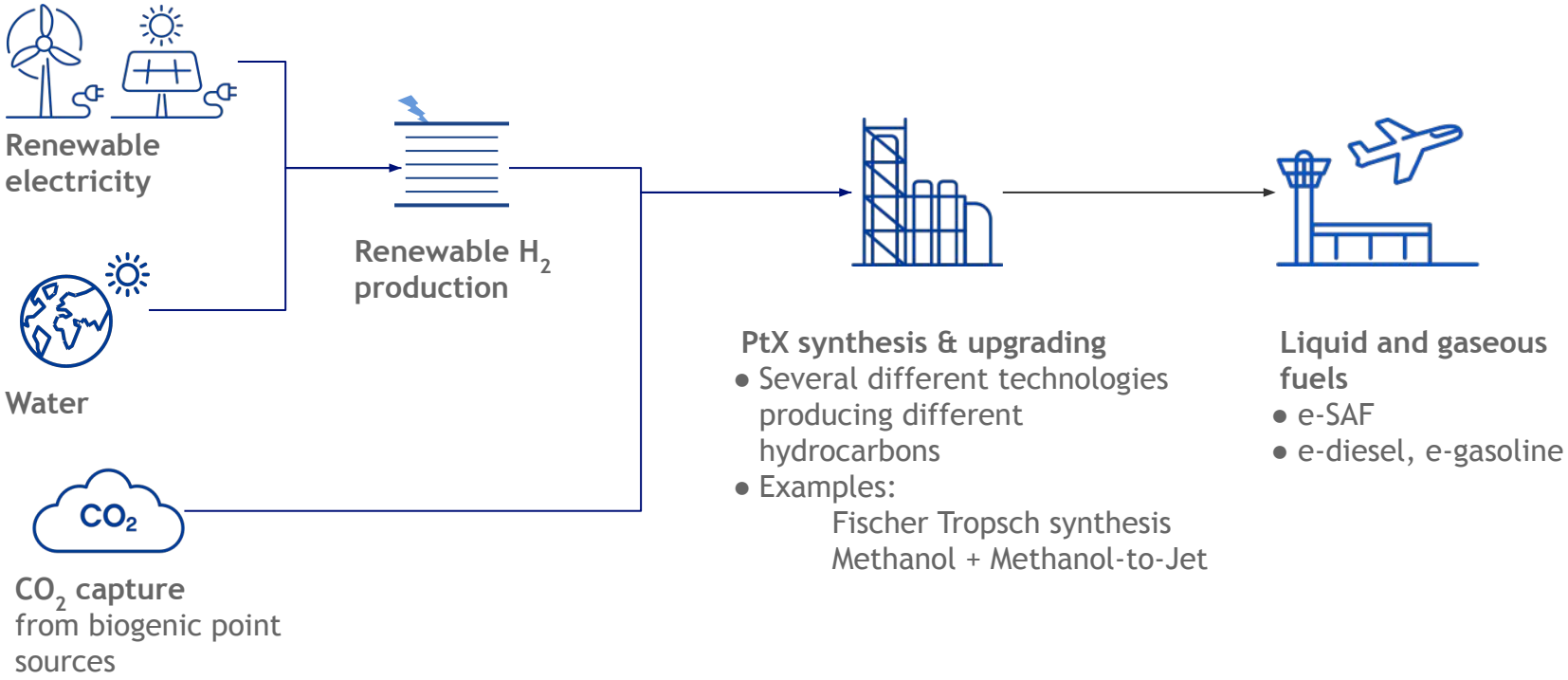
Other ASTM International developments for SAF and synthetic fuels

- **Co-processing is currently allowed at low percentages for SAF production in conventional refineries**

- **Standardization and developments already on-going by ASTM International task forces also to enable 100 % synthetic fuel / SAF use in future**
  - 100% Drop-in synthetic fuel / SAF
  - 100% Non-drop-in synthetic fuel / SAF

  - **Several test flights and programs have been done for both of these options by the industry stakeholders for technical demonstration and research purposes. Examples:**
    - ECLIF3 project; Airbus, Rolls Royce, DLR, Neste
    - 100 % SAF flight with regional aircraft; Braathens regional airlines, ATR, P&WC, Neste

eSAF is Sustainable Aviation Fuel which is made of renewable electricity and carbon dioxide



Relevant eSAF facts

Renewable electricity and carbon capture

- Wind, solar, geothermal and hydropower as sources of renewable electricity. EU has strict electricity sourcing rules
- CO_2 is captured from biogenic point sources. Fossil CO_2 is not allowed in EU after 2041.

Power-to-liquid

- Electrolyser breaks water into hydrogen (H2) and oxygen using electricity
- Option 1: H2 and CO2 are synthesized into eCrude and upgraded to eSAF (Fischer Tropsch process)
- Option 2: H2 and CO2 are synthetized into methanol. Methanol-to-Jet-process is used to produce eSAF

e-SAF

- Synthetic aviation fuel produced using renewable energy
- FT technology and FT-based synthetic jet fuel are already approved in ASTM standards
- Methanol-to-Jet process is still under development and is not yet approved in ASTM standards

Commercial realities today

- High cost ⇒ high price
- No commercial scale eSAF production units yet

⇒ needs green hydrogen ecosystems ramp-up

⇒ needs significant investments for scaling

⇒ mandates are needed to create demand and growth with current price structure

New aircraft and propulsion technologies in future - Hydrogen and electric

Source: IATA Net zero 2050: new aircraft technology

Historical reflections

Every new aircraft generation has reduced emissions 15-20% (due to engines, aerodynamics, reduced weight)

New technologies

New aircraft and propulsion technologies for future under development

Timeline

Viability potential from mid 2030s onwards => incl. hybrid-electric, fully electric, hydrogen technologies

Hybrid-electric

Combining the advantages of both combustion and electric engines

Electric

Electric energy stored in batteries or fuel cells

Hydrogen

can replace jet fuel in conventional engines and can also be used in fuel cells for electrical power

New aerodynamic design

canard wing, blended wing, strut or truss-braced wing

Additional info:

IATA Aircraft Technology Net Zero Roadmap

The regulatory framework needed for SAF deployment and scale-up

SAF mandates and other policy frameworks are being established across the globe

Americas

British Columbia (Canada)	-1.7%	-10%[1]
Canada federal	Opt-in	Opt-in[2]
US state level	LCFS opt-in CA, OR; incentives IL, WA	+ LCFS in IL, MN, MI, NM, NY
US federal	RFS opt-in; SAF BTC / CFPC[3]	RFS opt-in, TBA
Brazil	1% (2027)	

- Market growth in the US driven by a mix of federal and state level incentives (opt-ins and tax credits)
- British Columbia plans to implement an aviation specific emission reduction target
- First LatAm SAF mandate expected for Brazil

EMEA

European Union	2%	6%[4]
United Kingdom	TBA	10%[5]
Turkey, UAE	Policies considered	

- SAF mandates in place (NOR, SWE, FRA) to be superseded by an EU-wide SAF mandate in 2025
- UK plans to follow similar timeline
- Policy discussion starting in the Middle East

Asia Pacific

Japan	TBA	10%[6]
New Zealand	TBA	TBA
Singapore	TBA	TBA
South Korea India, Australia	Policies considered	

2025
2030

- Frontrunner countries such as Japan and New Zealand setting comparable targets and timelines for SAF adoption as Western peers
- SAF policy discussion spreading to an increasing number of countries

1) Intentions Paper proposal to introduce a carbon intensity reduction target for jet fuel starting in 2024, with -10% CI target in 2030; 2) Canada federal Clean Fuel Standard 3) BTC (Blenders Tax Credit) expected to change to a CFPC (Clean Fuel Production Credit) in 2025; 4) Provisional agreement on ReFuelEU Aviation with 2030 level of 6% including 1.2% RFNBO sub-mandate; 5) UK Net Zero Strategy; 6) METI proposal on May 26, 2023.

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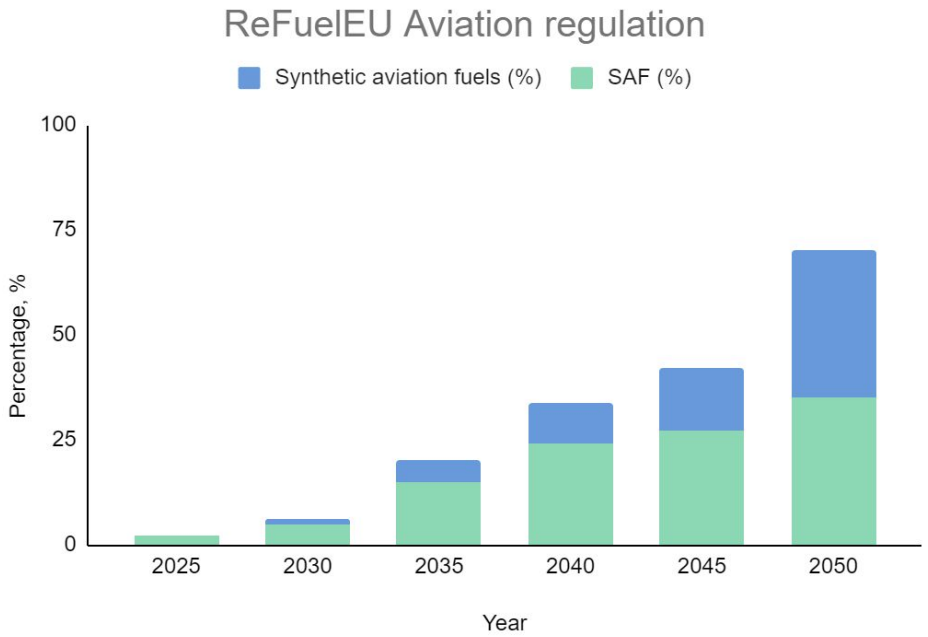
ReFuelEU Aviation regulation is part of European Union´s Fit for 55 package

Fit for 55: EU's target of reducing net greenhouse gas emissions by at least 55% by 2030

ReFuelEU Aviation obligates aviation fuel suppliers to supply an increasing share of sustainable aviation fuel at European Union airports; including also increasing share of synthetic fuels to decarbonise the aviation sector.



Source: European Council (Council of the European Union), European Parliament

Neste´s SAF availability

1.5 Mt/a

SAF capacity

Capacity in early 2024 with completed Singapore refinery expansion and ongoing investments in the Rotterdam refinery

>70

Customers

Direct customers across the aviation supply chain, i.e. fuel suppliers, airlines, corporates and travel & cargo companies

21

Countries

Neste's SAF is used in a growing list of countries across Europe, Americas, Middle East and Asia-Pacific

>25

Key airports[1]

Neste MY Sustainable Aviation Fuel is available either directly from Neste or via a channel partner at key aviation hubs around the world

Neste MY Sustainable Aviation Fuel reduces GHG emissions by up to 80 % over the lifecycle compared to fossil jet fuel

1) Including airports with over 1 million passengers where branded Neste MY Sustainable Aviation Fuel is available to airline customers, either directly from Neste or via a channel partner; Neste MY SAF is also available at several smaller and general aviation airports

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Change runs on renewables