Sustainable Fuels for Aviation

aireg

Aviation Initiative for
Renewable Energy in Germany e.V.

Introducing aireg: Vision and goals

aireg Aviation Initiative for Renewable Energy in Germany e.V.

- Founded in 2011 as an association of companies and organizations from industry, research, and science
- Availability and use of renewable energies in aviation in order to achieve the aviation industry's ambitious CO_2 reduction targets

What does aireg stand for?

Reliable regulatory framework

Consistent commitment to European regulation, in particular the SAF mandates of the ReFuelEU Aviation Regulation, as a key instrument for supporting the market ramp-up of sustainable aviation fuels (SAF).

Ambitious target achievement

Exceeding the specified SAF mandates for climate protection reasons and to actively support the ICAO's international climate targets in the area of sustainable aviation fuels.

Strengthening incentive systems

Further development and expansion of market-effective support and incentive mechanisms for the broader use of SAF in German and European aviation.

Reliable and sustainable value creation

Establishment of import structures for hydrogen derivatives to Germany in order to fulfill SAF mandates, while ensuring that a significant portion of industrial value creation remains in Germany—with the aim of securing technological leadership and strengthening national energy and supply sovereignty.

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59 Members

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Thorsten Luft
Beratung für Treibstoffmanagement und Sustainable Aviation Fuels

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Cooperation Agreements and Memberships

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Cooperation Agreements

Memberships

Strategy Paper

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- Strategy paper published for ILA 2024 – Germany as a leading market for sustainable aviation fuels (SAF)
- aireg sees itself as a competence network and open transformation platform whose members can be classified into four subject areas (Aviation; Fuel Producers; Research, Development & Consulting; Policy) and develop new approaches and innovative concepts for achieving the ambitious usage targets for SAF

Organizational Structure

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General Assembly

Executive Board

Six members of the Board

Advisory Council

Advisory Council members from science, industry and politics

Coordinating Committee

Consisting of the Executive Board and the chairs of the WGs

Auditors and Head Office

Working Groups and Task Force

- Resources and Technologies
- Quality, Certification and Use
- Sustainability
- Task-Force Economy and Production




Our Executive Board

Siegfried Knecht
Chairman of the Board

Uwe Gaudig
Deputy Chairman of the Board

Prof. Dr.-Ing. Martin Kaltschmitt
Deputy Chairman of the Board

Melanie Form
Member of the Board
Managing Director

Prof. Dr.-Ing. Manfred Aigner
President for Science and Research

Prof. Dr. Jürgen Ringbeck
President for Industry and Aviation

Our Statues

How does aireg work?

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Working Groups and Task Force

Resources and Technology
Examine available feedstocks and production options for sustainable, renewable aviation fuels

Quality, Certification and Use
Practical use of sustainable, renewable aviation fuels and challenges of quality and certification

Sustainability
Considering all three pillars of sustainability – environment, social equity and economy – along the entire value chain

Task Force Economy and Production
Examination of economic aspects and potential production capacities of sustainable, regenerative aviation fuels

How does aireg work?

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- **Network:** Our members cover the entire value chain for SAF. The office is happy to establish contacts for exchange purposes as needed.
- **airegNews:** Our weekly newsletter keeps our members up to date on everything related to SAF. Our SonderairegNews provides short-term information on current developments, such as draft legislation.
- **Events:** Biennial conference on SAF and participation in other high-profile industry gatherings (ILA, Aviation Evening, etc.)

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Climate Protection Plan of International Aviation in the face of major growth

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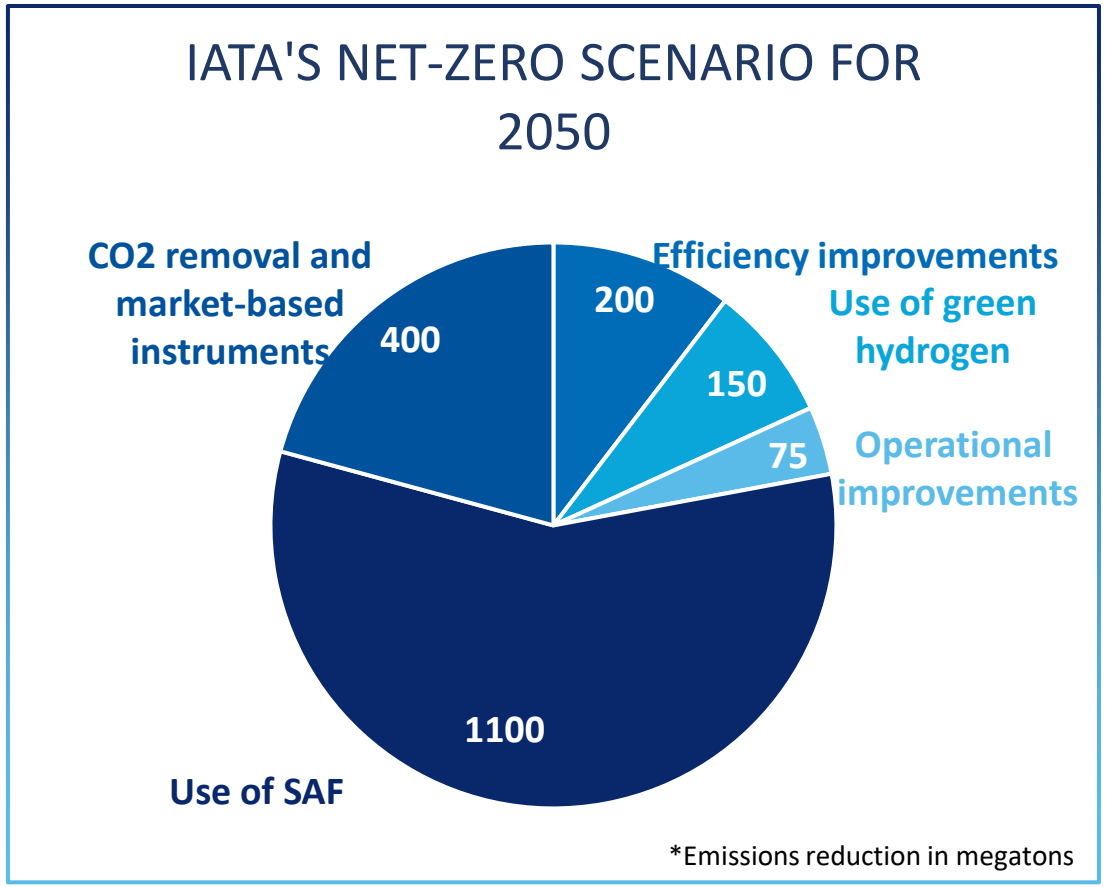
! Growth by 2050: ICAO expects revenue passenger kilometer (RPK) to double or even triple by 2050.

→ At least doubling of the climate impact if no measures are taken. !

IATA has developed a net-zero scenario for global aviation in 2050. Renewable energies (SAF and green hydrogen) contribute 65% to the total reduction in emissions.

- **Use of SAF (57%):** IATA expects SAF to account for 80%–90% of fuel used by 2050.
- **CO2 removal and market-based instruments (21%):** DAC and offsetting create negative emissions.
- **Efficiency improvements (10%):** Modern aircraft and engines require less energy for their flights.
- **Use of green hydrogen (8%):** Green hydrogen is used on short- and medium-haul flights.
- **Operational improvements (4%):** Efficiency gains through investments in operations and infrastructure



Source: IATA (2023): IATA Sustainability and Economics, ICAO LTAG SAF availability scenarios

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Emissions from the Combustion of Kerosene

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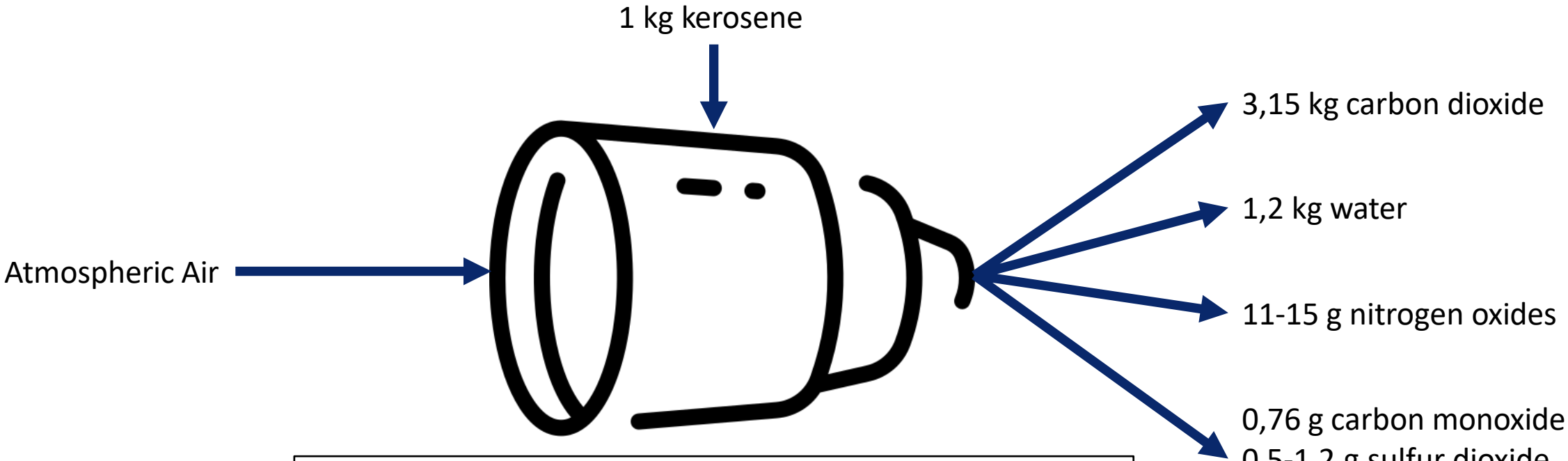

! The **climate impact** of specific emissions from the combustion of kerosene is the subject of current **research projects**, for example at the DLR. !

BAZL (2020): CO2-Emissionen des Luftverkehrs: Grundsätzliches und Zahlen.
Lee et al., Atmos. Environ., https://doi.org/10.1016/j.atmosenv.2020.117834,

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Why SAF to reduce Climate Impact?

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Lower GHG emissions

- Already up to 80% less GHG emissions with HEFA-SAF compared to fossil kerosene
- With electricity-based SAF potentially up to 100% CO_2 emission reduction

Reduction of non-CO_2 effects

- Result from the formation of soot particles and other climate-impacting substances
- SAF burns cleaner with reduced formation of particles

Lack of Alternatives

- Other climate-friendly propulsion systems (electric/ hydrogen) will be available from 2040 at the earliest
- Duration of market ramp-up very high due to long service life of aircraft

Drop-in solution

- No adaption of engines and tank infrastructure necessary
- Commercially available and in use today
- Already approved in admixtures up to 50%

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Overview of Approved SAF Options

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ASTM	Annex	Year of Approval	Process	Blending Limit	Possible Feedstocks
D7566	1	2009	FT-SPK	50 Vol.-%	flexible (biogen, fossil, synthetic, e.g. PtL or BtL)
D7566	2	2011	HEFA-SPK	50 Vol.-%	fats/oils (e.g. plant-based oils, used cooking oils)
D7566	3	2014	HFS-SIP	10 Vol.-%	sugar, starch, lignocellulose
D7566	4	2015	FT-SPK/A	50 Vol.-%	flexible (biogen, fossil, synthetic, e.g. PtL or BtL)
D7566	5	2016	ATJ-SPK	50 Vol.-%	sugar, starch, lignocellulose
D7566	6	2020	CH-SK	50 Vol.-%	fats/oils (e.g. plant-based oils, used cooking oils)
D7566	7	2020	HC-HEFA-SPK	10 Vol.-%	fats/oils (algae oil)
D7566	8	2023	ATJ-SKA	50 Vol.-%	sugar, starch
D1655	1	2018	Co-Processing (HEFA-SPK)	30 Vol.-%	fats/oils (e.g. plant-based oils, used cooking oils)
D1655	1	2020	Co-Processing (FT-SPK, FT-SPK/A)	5 Vol.-%	FT-biocrude (primary feedstocks see FT-SPK, FT-SPK/A)
D1655	1	2023	Co-Processing (of HEFA)	24 Vol.-% (Feedstock) 10 Vol.-% (Product)	hydroprocessed biomass

ATJ-SPK (Alcohol to Jet Synthetic Paraffinic Kerosene), **ATJ-SKA** (Alcohol to Jet Synthetic Paraffinic Kerosene with Aromatics), **CH-SK** (Catalytic Hydrothermolysis Synthesized Kerosene), **FT** (Fischer-Tropsch), **HC** (Hydrocarbons), **HEFA** (Hydroprocessed Esters and Fatty Acids), **HFS-SIP** (Hydroprocessed Fermented Sugars to Synthetic Isoparaffins), **PtL** (Power-to-Liquid), **SPK** (Synthetic Paraffinic Kerosene), **SPK/A** (Synthetic Paraffinic Kerosene with Aromatics)

In addition to **biogenic SAF** and **electricity-based SAF**, there is the option of combining these pathways. These SAF are called **hybrid SAF**.

Source: based on CAAFI (2025)

Biogenic SAF Production Pathways

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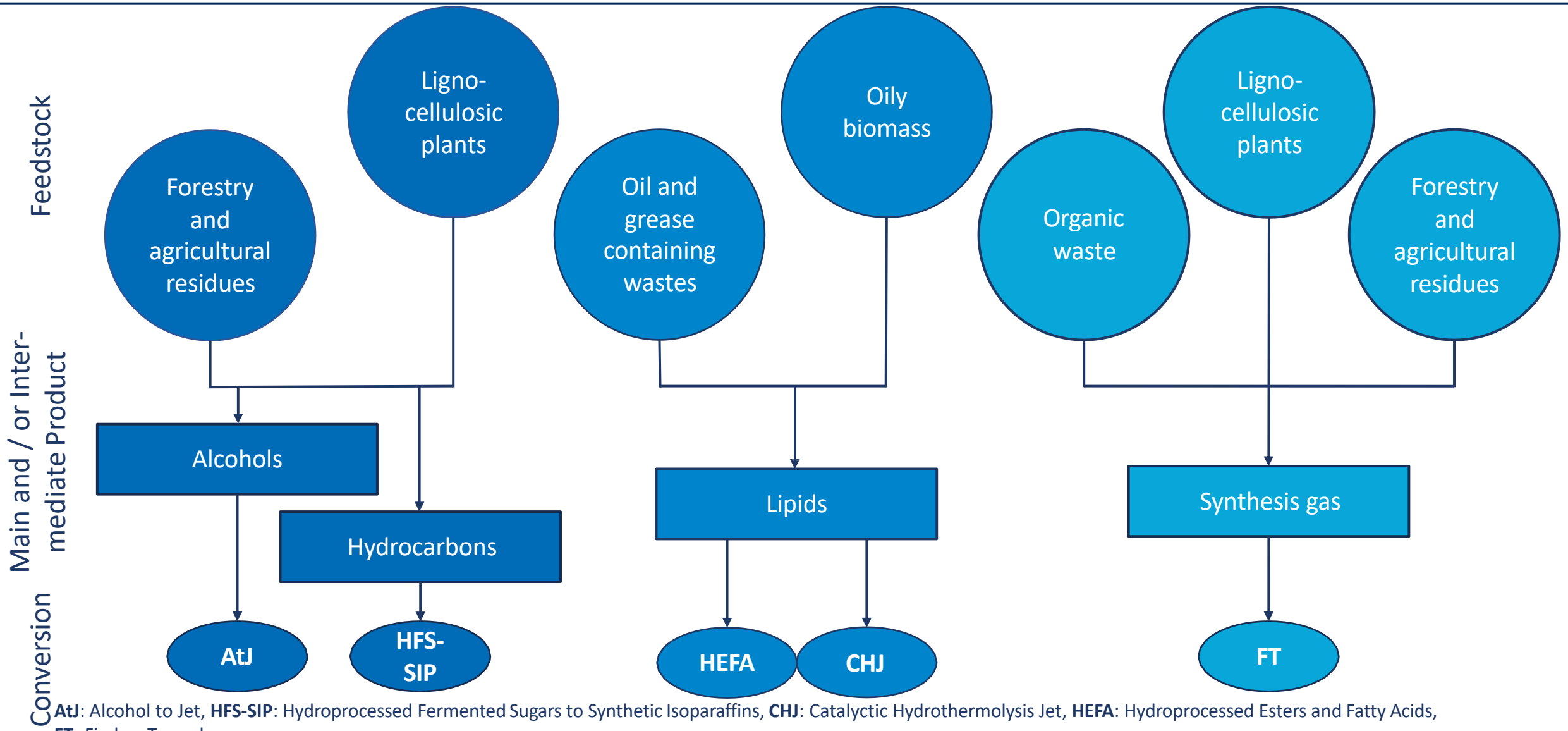

AtJ: Alcohol to Jet, **HFS-SIP**: Hydroprocessed Fermented Sugars to Synthetic Isoparaffins, **CHJ**: Catalytic Hydrothermolysis Jet, **HEFA**: Hydroprocessed Esters and Fatty Acids, **FT**: Fischer-Tropsch

Source: Based on Thomson et al. 2020): Sustainable Aviation Fuels. The Best Solution to Large Sustainable Aircraft

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Electricity-based SAF – Power to Liquid (PtL)

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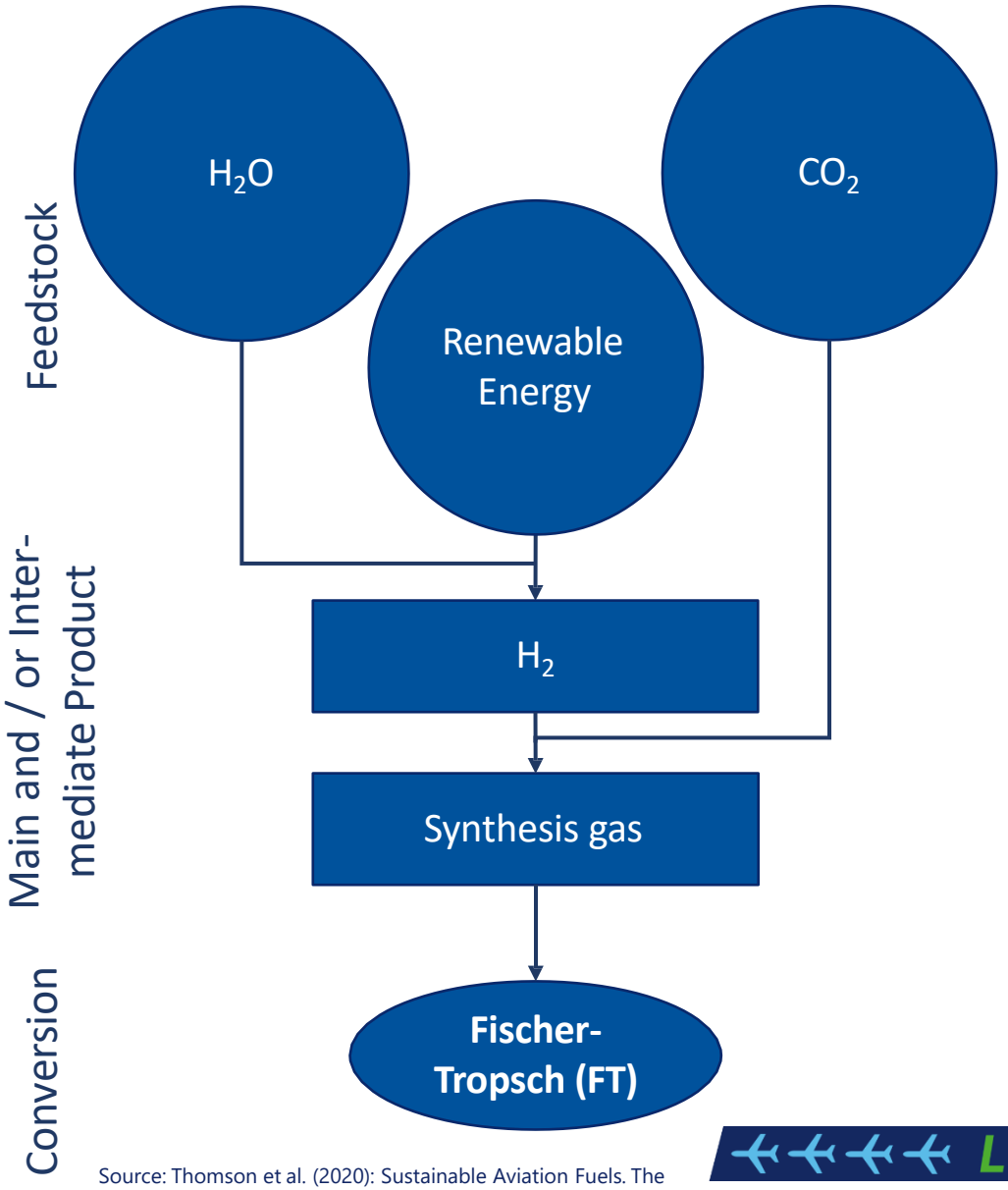
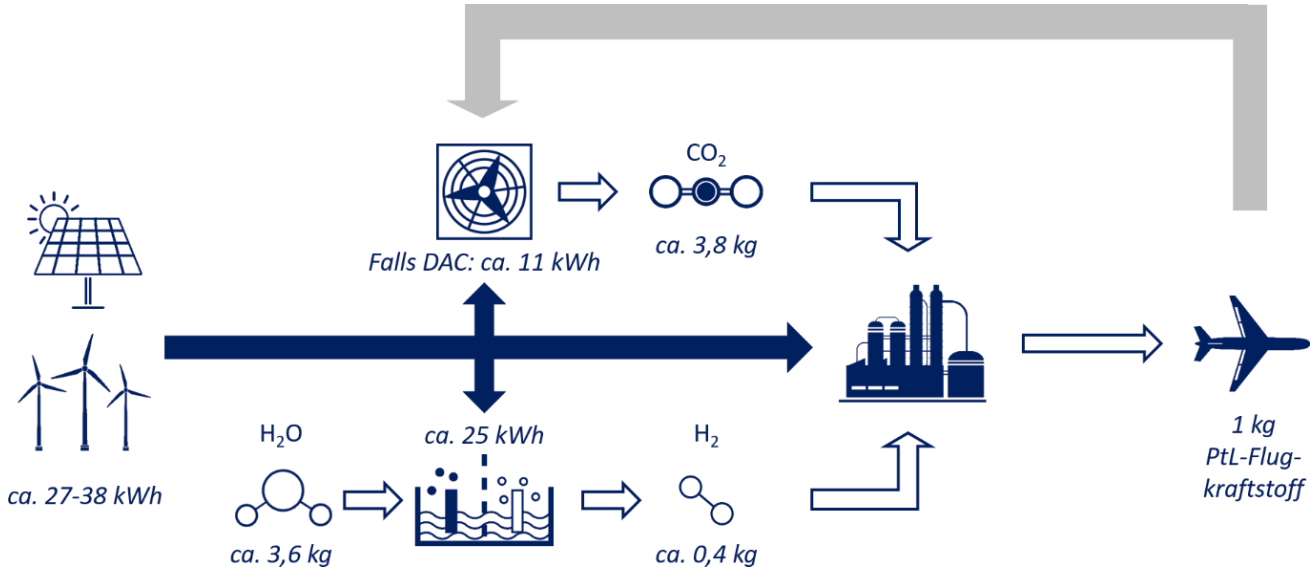


Source: Thomson et al. (2020): Sustainable Aviation Fuels. The Best Solution to Large Sustainable Aircraft

Quantitative overview of required feedstocks in the PtL production pathway:



Feedstock required to operate all domestic German flights with PtL:

- Demand of about 700,000 tons of kerosene (comparison year 2019).
- At least 19,000 GWh of renewable energy -> 750 to 2,500 wind turbines
- 280,000 tons of hydrogen ≙ 9 TWh hydrogen -> 10% of Germany's hydrogen demand in 2030 according to hydrogen strategy of the Federal Government of Germany
- 2.7 million tons of biogenic CO2 -> potential of CO2 capture of approx. 13 million tons from biogas, biomethane and bioethanol production in Germany

Source: aireg e.V. / TUHH (2023): Ptl Factsheet

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Kerosene Consumption

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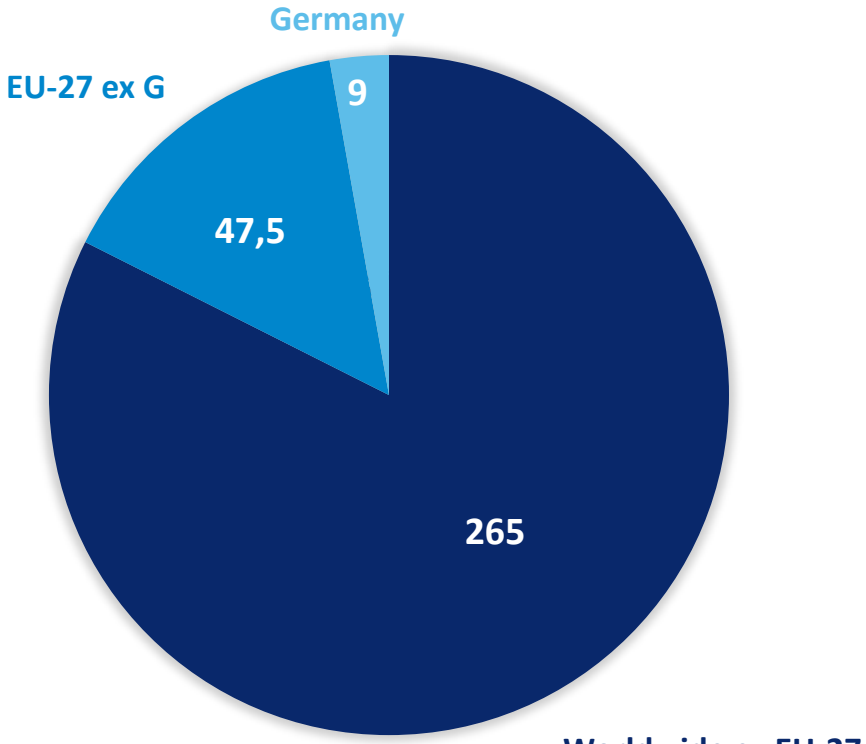
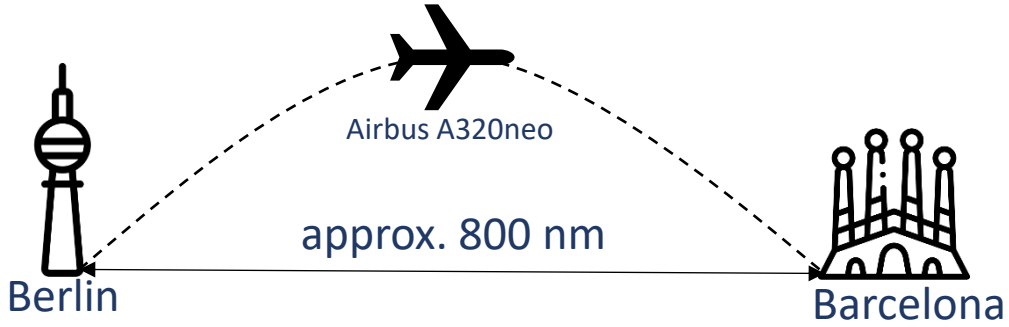
GLOBAL KEROSENE CONSUMPTION IN MILLIONS OF TONS IN 2024



In 2024, German airlines achieved an average fuel consumption of 3.38 liters of kerosene per 100 passenger kilometers. To estimate the scale of individual flights, a number of realistic assumptions were made.

Realistic consumption: 40-55 tons kerosene



Realistic consumption: 5-7 tons kerosene

Sources: Statista - Weltweiter Treibstoffverbrauch aller kommerziellen Fluggesellschaften von 2004 bis 2025
EC – Supply and transformation of oil and petroleum products
BDL - Kerosinverbrauch der deutschen Fluggesellschaften sinkt auf durchschnittlich 3,38 Liter pro Passagier und 100 Kilometer

ReFuelEU Aviation

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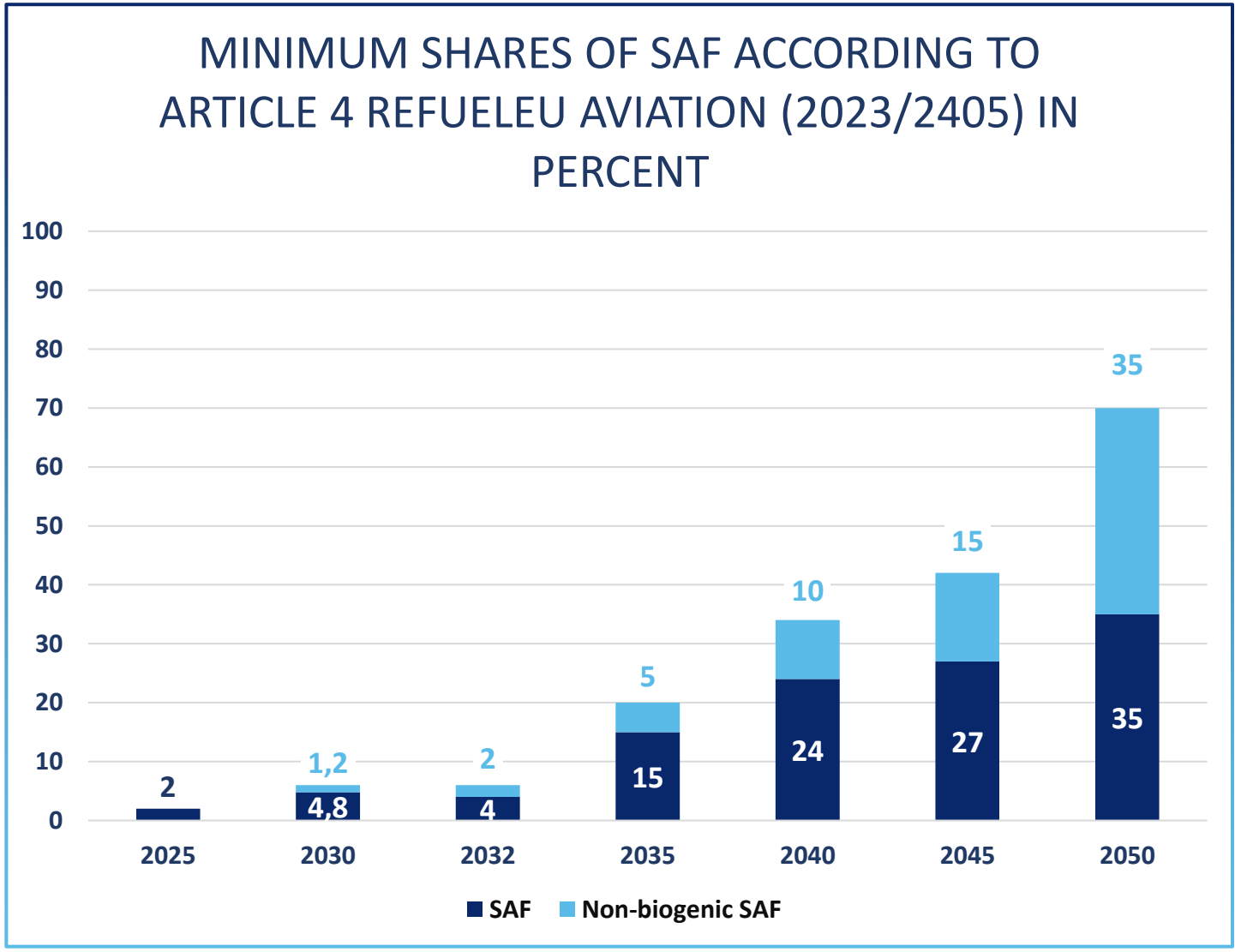
To stimulate the market ramp-up of SAF, the European Commission adopted the ReFuelEU Aviation regulation in 2023. Part of this initiative includes minimum quotas for distributors of aviation turbine fuel, which must be met from 2025 onwards. One percent corresponds to approximately 550,000 tons of aviation turbine fuel.



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Prices for SAF

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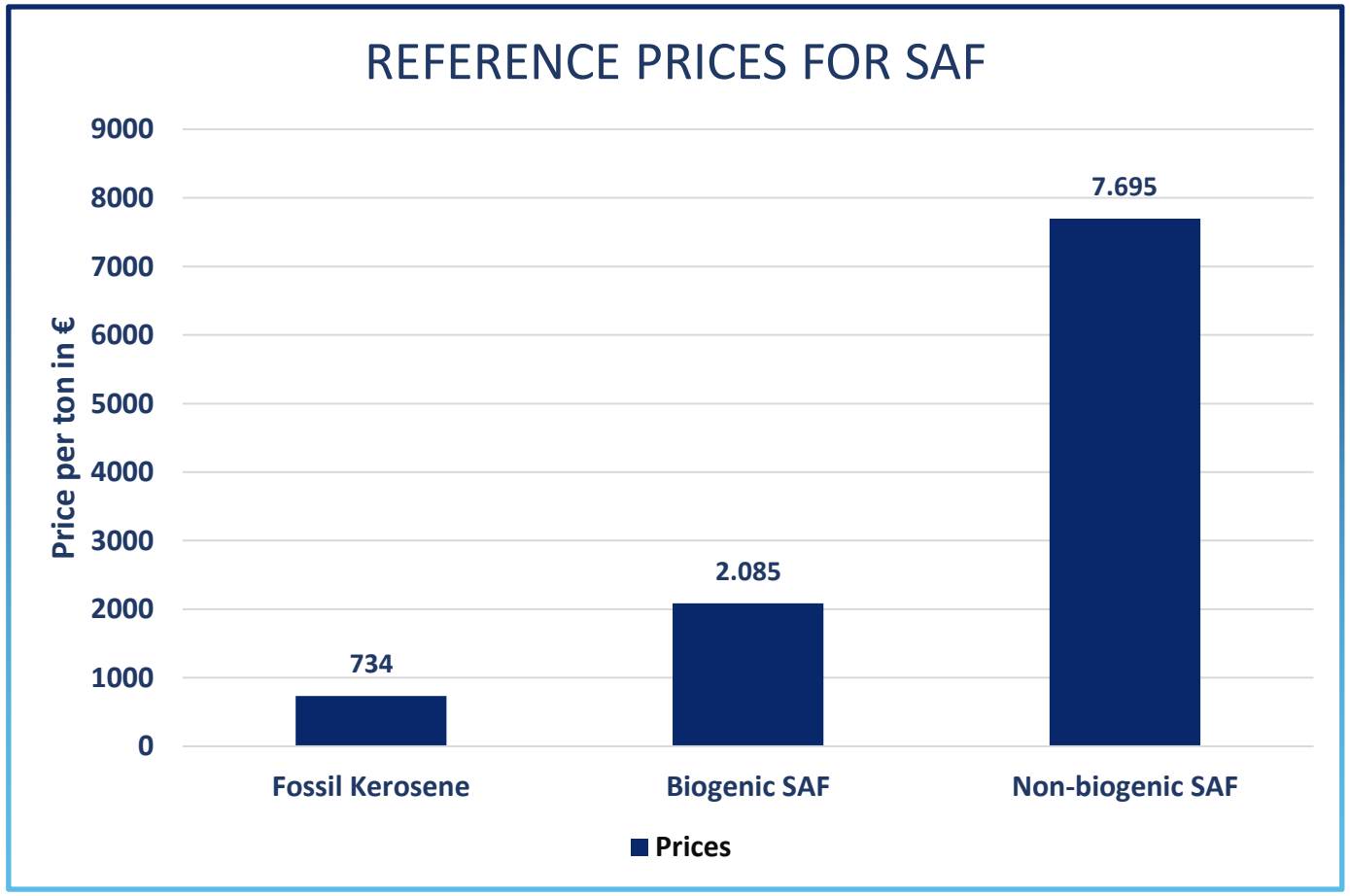
The reference prices (for SAF allowances/FEETS, among other things) are recorded annually in a report by EASA.



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Source: EASA – Aviation Fuels Reference Prices for ReFuelEU Aviation

Announced SAF volumes in 2030

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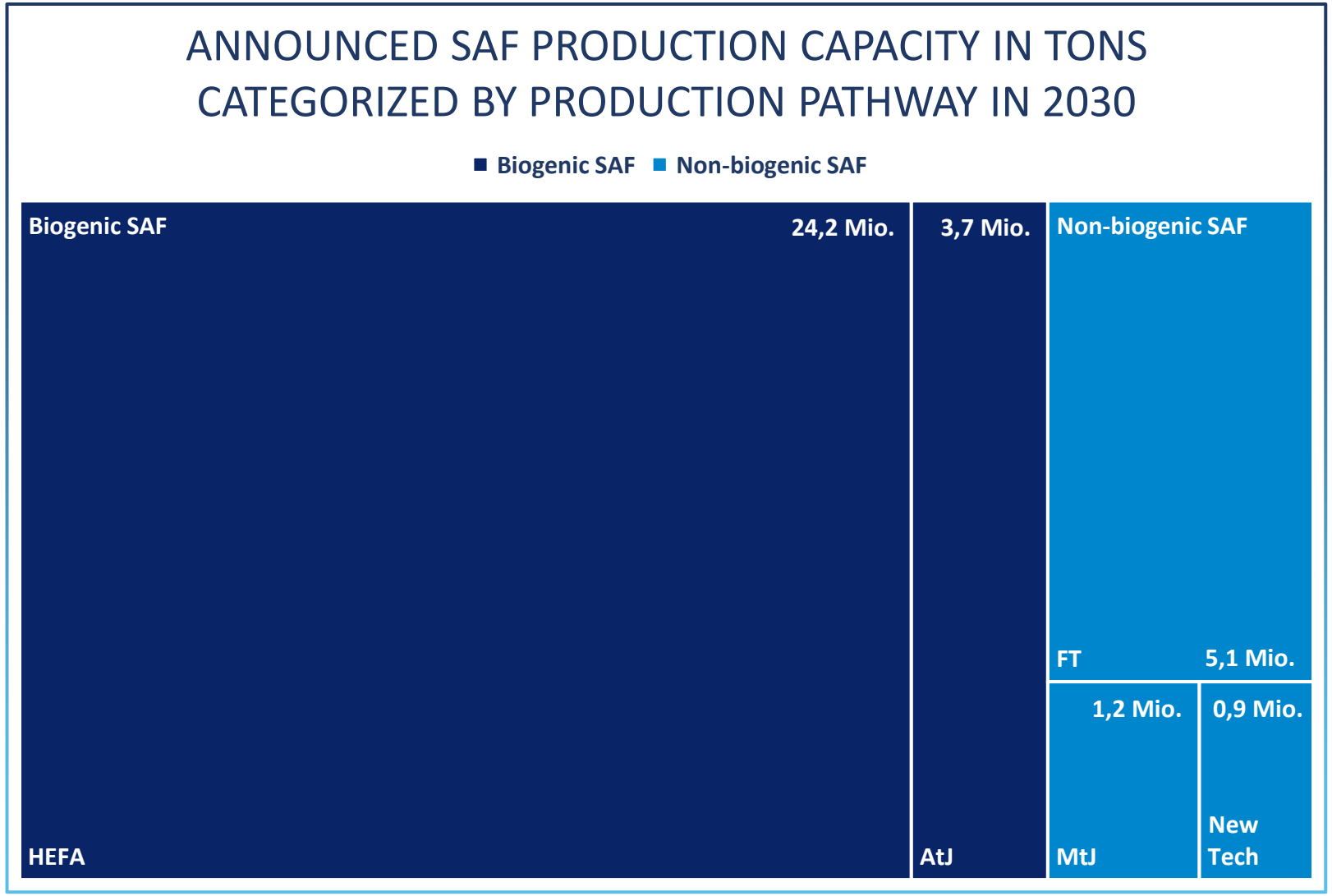
In its annually updated SAF Outlook, CENA Hessen examines the SAF production volumes announced worldwide, categorized here by production pathway.



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Source: CENA Hessen - SAF-Monitor

Overview of Global SAF Regulations

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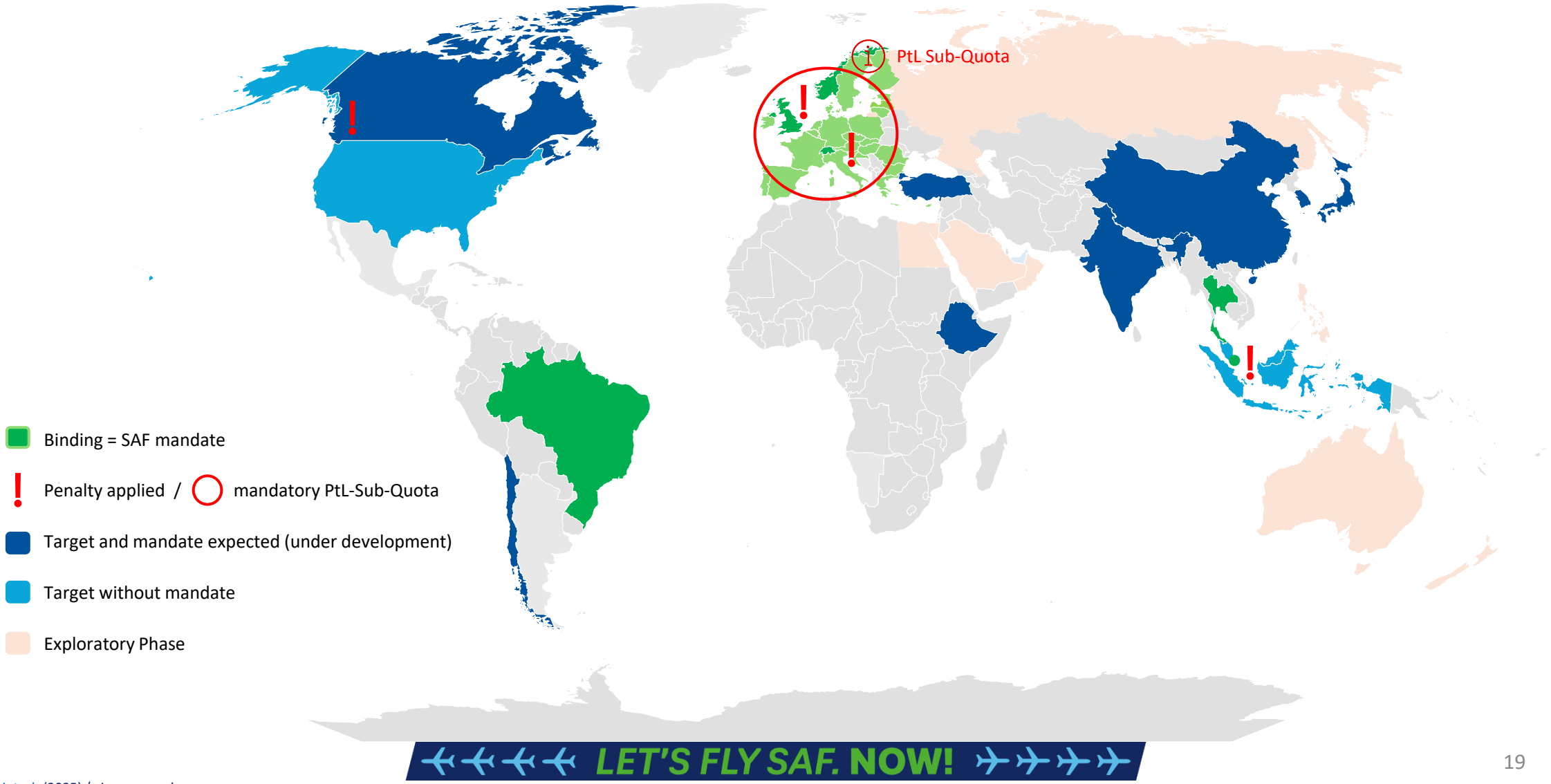

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Source: Noviqtech (2025) / aireg research

Asia-Pacific

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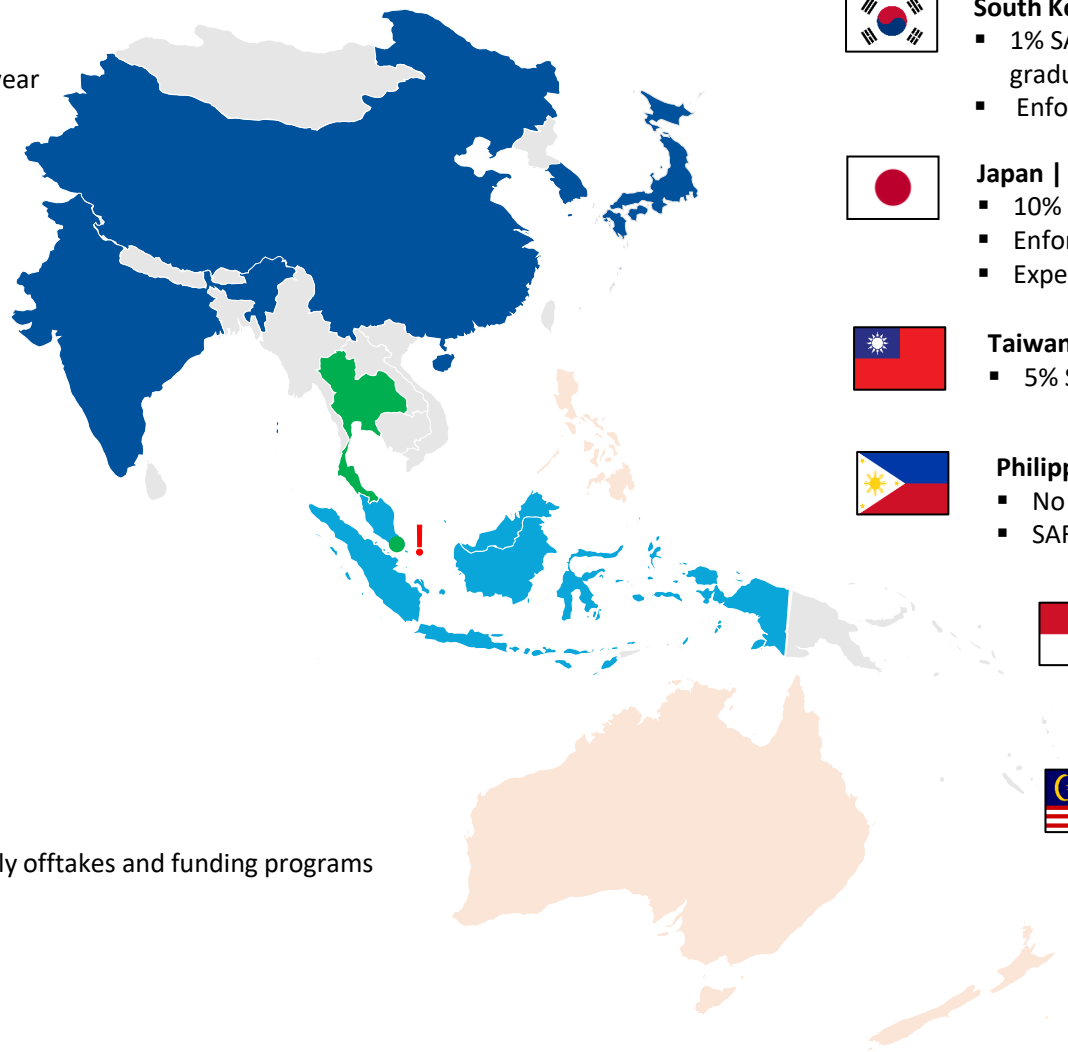

China | National SAF plan & mandate expected
- 50.000t SAF in 2025
- SAF blending mandate expected in 2026 with 15th 5-year plan: 2-5% in 2030
- China invests massively in production capacity
- Ambitious long-term targets expected

India | Target & Support
- 1% SAF target in 2027 on international flights; 5% in 2030
- Focus to attract SAF investments (especially ethanol feedstocks)

Thailand | SAF mandate & Support
- SAF mandate as a target from 2026
- 1% SAF in 2026; 1-2% in 2030; 8% in 2036
- Enforcement mechanisms

Singapore | SAF Levy
- SAF levy on tickets from 2026
- 1% in 2026; target 3-5% in 2030
- ! Mandatory and penalties

Australia | Exploratory Phase
- No binding SAF blending
- Focus on feasibility studies, domestic feedstocks, early offtakes and funding programs
- Government supports policy direction

New Zealand | Exploratory Phase
- No binding SAF blending
- Early policy discussions ongoing

South Korea | Target & mandate expected
- 1% SAF target in 2027 on international flights; gradual increase
- Enforcement and penalties under development

Japan | Target & mandate expected
- 10% SAF target by 2030
- Enforcement and reporting under development
- Expected scope domestic and international flights

Taiwan | Target
- 5% SAF target in 2030

Philippines | Exploratory Phase
- No binding SAF blending
- SAF policy framework and feedstock studies underway

Indonesia | Target & Roadmap
- 1% SAF target by 2027; 2.5% in 2030
- National SAF roadmap sets blending goals
- Implementation details pending

Malaysia | Target & Framework
- 1% SAF target by 2027; 47% in 2050
- Consultation stage
- Scaling tied to domestic biofuel roadmap

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Source: Novigtech (2025) / aireg research

Russia, Caucasus, Near & Middle East

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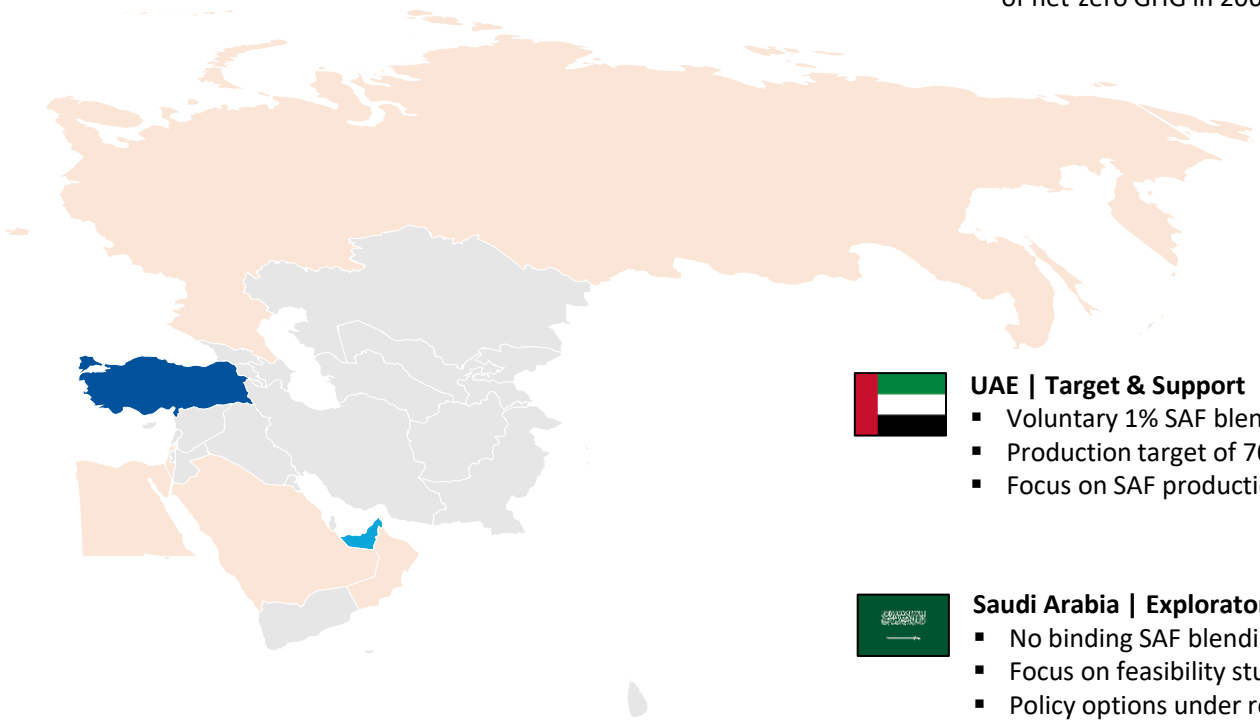
Russia | Exploratory Phase & Development
- No binding SAF blending
- Focus on SAF production development
- Russia has committed to a general national goal of net-zero GHG in 2060

Turkiye | Target & mandate expected
- 1% SAF target in 2025; 5% by 2030 on international flights
- Target included In national decarbonisation roadmap and aviation GHG reduction plan
- Formal regulatory text pending



Israel | Exploratory Phase & Development
- No binding SAF blending
- Active development of a SAF-strategy targeting net-zero aviation in 2050
- Plans to implement a SAF blending mandate

UAE | Target & Support
- Voluntary 1% SAF blending target
- Production target of 700 mio. liters SAF annually by 2030
- Focus on SAF production support and PtL-pilot plants

Egypt | Exploratory Phase & Support
- No binding SAF blending
- Focus on developing SAF production capabilities and to align with international environmental standards

Saudi Arabia | Exploratory Phase
- No binding SAF blending
- Focus on feasibility studies and funding programs
- Policy options under review

Oman| Exploratory Phase
- No binding SAF blending
- Focus on R&D studies and renewable hydrogen projects

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Source: Noviqtech (2025) / aireg research

The Americas

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Canada| Target & Support
- No binding SAF blending
- Aspirational use goal of 10% in 2030
- SAF usage generates credits under the Clean Fuel Regulations

British Columbia | SAF Blending mandate
- Continents first provincial SAF mandate rule
- 1% by 2028; target 3% by 2030
- ! Mandatory and penalties

United States | Incentive lead growth
- No binding SAF blending
- 1.25-1.75 $/gal. SAF tax credit under Inflation Reduction Act
- State Low Carbon Fuel Standards (e.g. California) reward SAF use
- Federal goal of 10% SAF by 2030 remains voluntary

Chile | Target & Roadmap
- No binding SAF blending
- National SAF roadmap sets blending targets
- 50% target by 2050
- Policy focus on PtL-production from domestic renewable hydrogen

Brazil | SAF Blending mandate
- GHG mandate / SAF mandate from 2027
- 1% in 2027; 10% in 2037
- Allowance for a book-and-claim system

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Source: Noviqtech (2025) / aireg research

EU & UK

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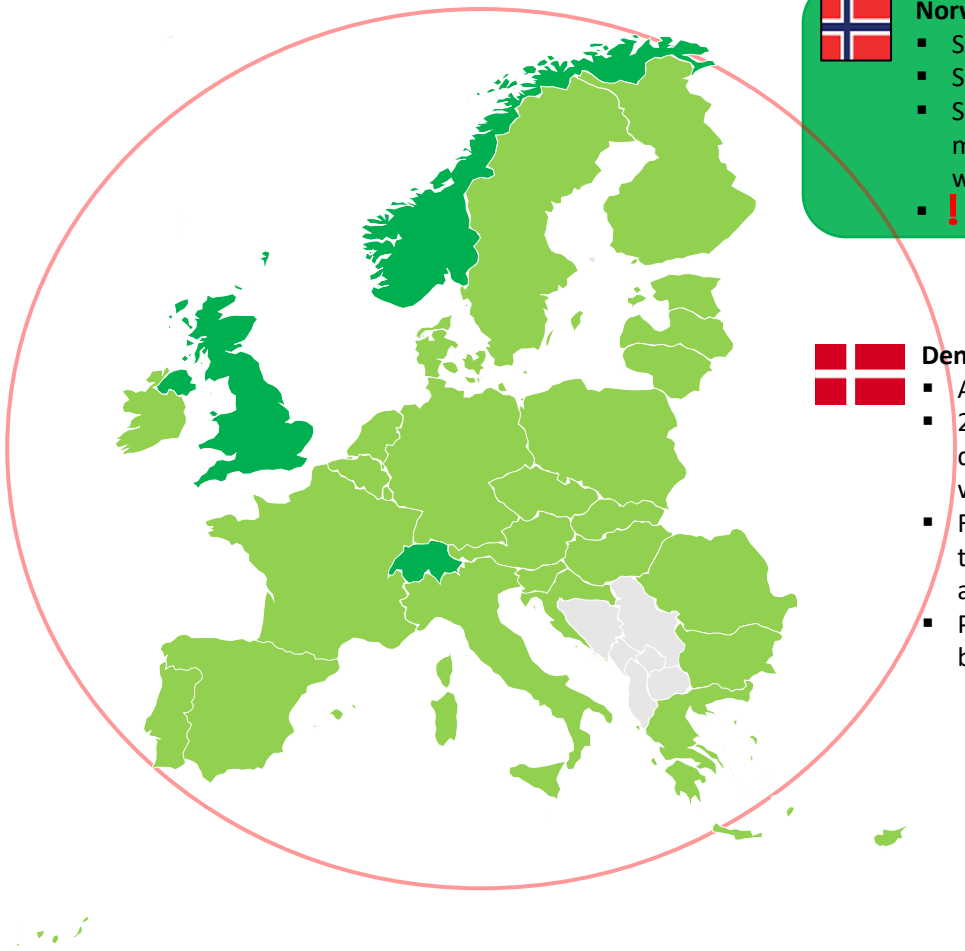
UK | SAF Blending mandate
- SAF blending mandate
- 2% SAF in 2025, 10% in 2030 and 22% in 2040
- Additional PtL quota starting in 2028 with 0.2%; 4.5% in 2040
- ❗ Mandatory and penalties: buy-out-mechanisms

EU | SAF Blending mandate
- SAF blending mandate (ReFuelEU Aviation)
- 2% SAF in 2025, 6% in 2030 and 70% in 2050
- Additional PtL/eFuel subquota starting in 2030 with 1.2%; 35% in 2050
- ❗ Mandatory and penalties: no buy-out-mechanisms; shortfall must be compensated in the next year

Switzerland | SAF Blending mandate
- SAF blending mandate
- Adoption and Integration of ReFuelEU Aviation regulations into Swiss legislation from 2025
- 2% SAF in 2026
- ❗ Mandatory and penalties



Norway | SAF Blending mandate
- SAF blending mandate
- Since 2020 national SAF quota of 0.5%
- Since 2025: Integration in ReFuelEU Aviation blending mandate and quotas; full integration planned in 2027 with 2% SAF quota
- ❗ Mandatory and penalties

Denmark | additional domestic SAF incentive scheme
- Additional domestic SAF incentive scheme
- 2025-2027 national SAF blend support of one domestic route with 40% SAF blend, targeting 20 weekly one way flights
- Funding by European Union (36 million Euros) to cover the cost difference between conventional kerosene and SAF
- Purpose to accelerate SAF usage beyond the EU SAF blending mandate

mandatory PtL-Sub-Quota

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Source: Novigtech (2025) / aireg research

Thank you for your attention!

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Contact:

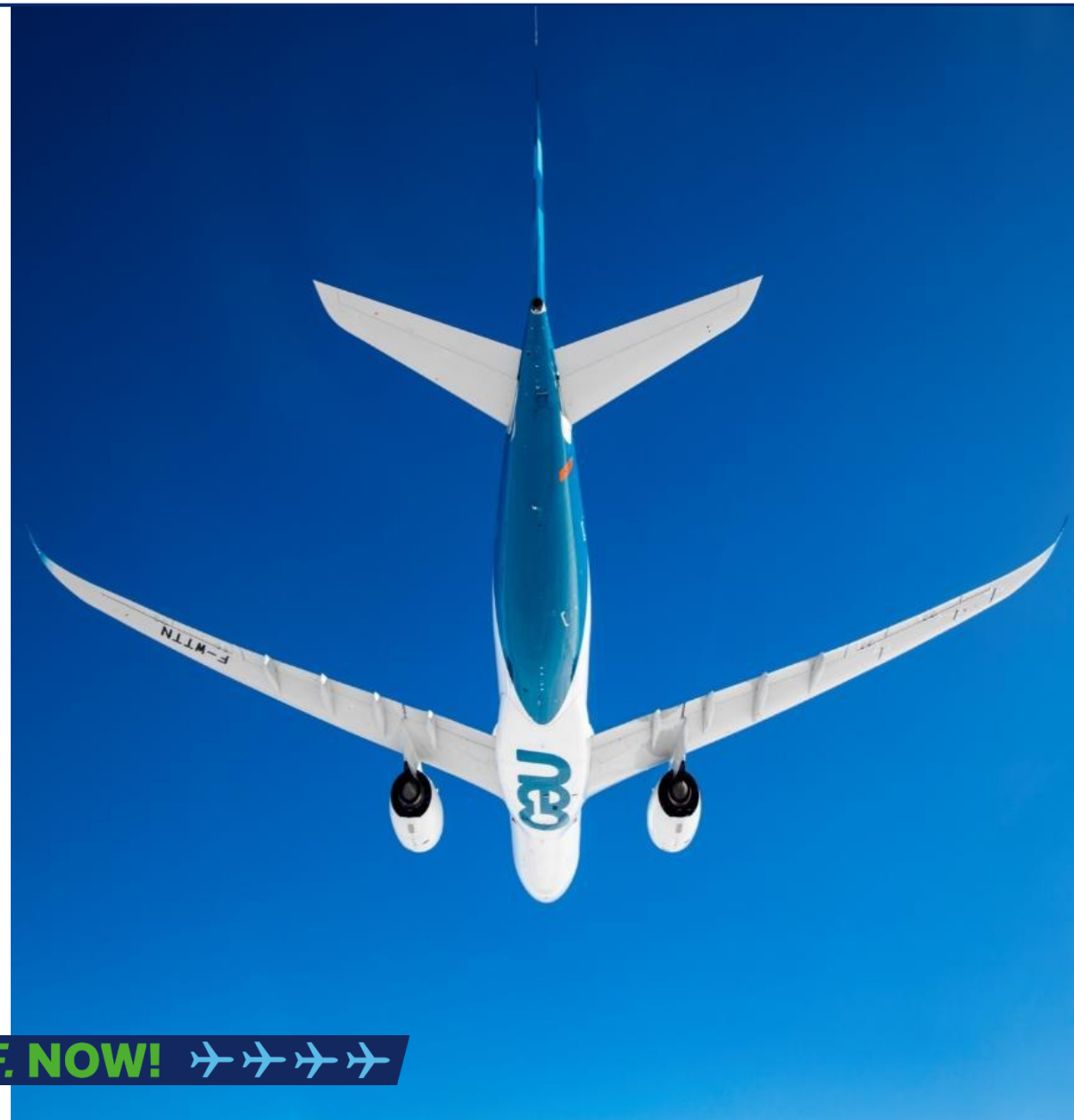
Melanie Form
Member of the Board
Managing Director

kontakt@aireg.de

aireg e.V. – Aviation Initiative for Renewable Energy in Germany

Bundesratufer 10
10555 Berlin

www.aireg.de



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