The European SAF policy landscape & ICAO SAF Rules of Thumb

The European SAF policy landscape

- ✓ **Case-Studies of European States' policies**
- ✓ **The European SAF map**
- ✓ **Feedstock and industrial potentials in Europe**
- ✓ **ICAO SAF Rules of Thumb: Estimating costs, investments, and production potential**

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The EU Green Deal

- To achieve climate neutrality, a 90% reduction in transport emissions is needed by 2050
- **ReFuel EU Aviation regulation**:
  - New EU regulation adopted in October 2023
    - Obligation on **all fuel suppliers** to distribute SAF in increasing amounts over time;
    - Obligation on **all airlines** to uplift (SAF-blended) aviation fuel **at EU airports** (anti-tankering measure);

European Commission

Sustainable aviation fuels – ReFuelEU Aviation

Council of the EU Press release 9 October 2023 10:20

RefuelEU aviation initiative: Council adopts new law to decarbonise the aviation sector

More renewable and low-carbon fuels will reduce the **carbon footprint** of the aviation sector and create a **level playing field** for a sustainable air transport in the EU following today's adoption of a new regulation by the Council on the so-called 'ReFuelEU aviation' initiative.

The new law will provide legal certainty to aircraft operators and fuel suppliers in Europe. By kick-starting the large-scale production of sustainable aviation fuels, it will soon make the EU's aviation sector much greener. This is a key step in our broader effort to reach our climate targets at European and global level.

— Raquel Sánchez Jiménez, Spanish acting minister of transport, mobility and urban agenda

ReFuel EU Aviation regulation

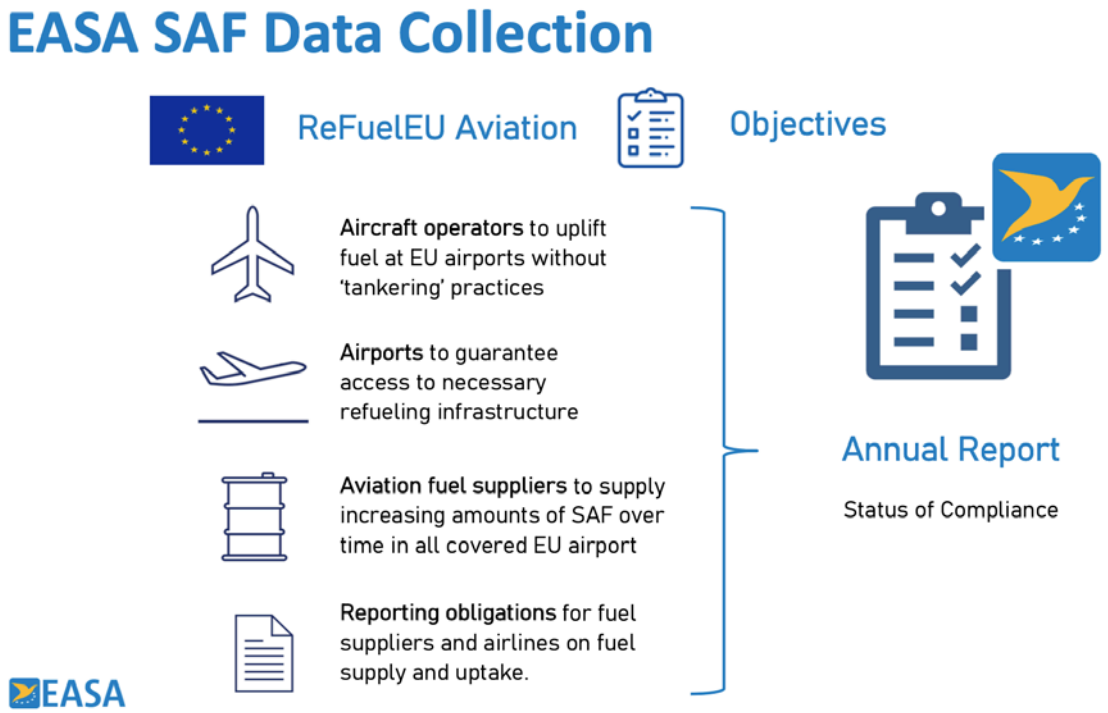
- Mandatory EU-wide SAF minimum supply shares:

	2025	2030	2035	2040	2045	2050
SAF	2%	6%	20%	34%	42%	70%
Synthetic aviation fuels	0%	1,2%*	5%	10%	15%	35%

*2030 & 2031: of which each year a minimum share of 0,7 %
2032 & 2033: of which each year a minimum share of 1,2 %
2024: of which each year a minimum share of 2 %

- Obligations on:
  - **Aircraft operators** to uplift fuel at EU airports
  - **Airports** to guarantee access to refueling infrastructure
  - **Aviation fuel suppliers** to supply SAF at the EU airports
    - Reporting by aircraft operators and aviation fuel suppliers

ReFuel EU Aviation regulation



Source:

Case-Studies of European States' policies

- Other ECAC States also establishing SAF policies:
  - **Norway**: SAF blending mandate of **0,5% since 2020** to reach 30% by 2030
  - **Sweden**: SAF blending mandate of **1% since 2021** to reach 30% by 2030
  - **France**: SAF blending mandate **of 1% since 2022** to reach 2% in 2025 and 5% in 2030
  - **Germany**: **Synthetic Aviation Fuel** blending mandate of **0,5% since 2026** to reach 2% in 2030




Case-Studies of European States' policies

- Other ECAC States also establishing SAF policies:
  - **UK**: A consultation undergoing for a **SAF mandate from 2025** requiring at least 10% by 2030
  - **Switzerland**: The Federal Office of Civil Aviation has launched a Strategy promoting the development and use of SAF, with **blending mandates planned from 2025**
  - **Türkiye**: Regulation under development for a SAF blending mandate **of 1% since 2026** to reach 5% in 2030

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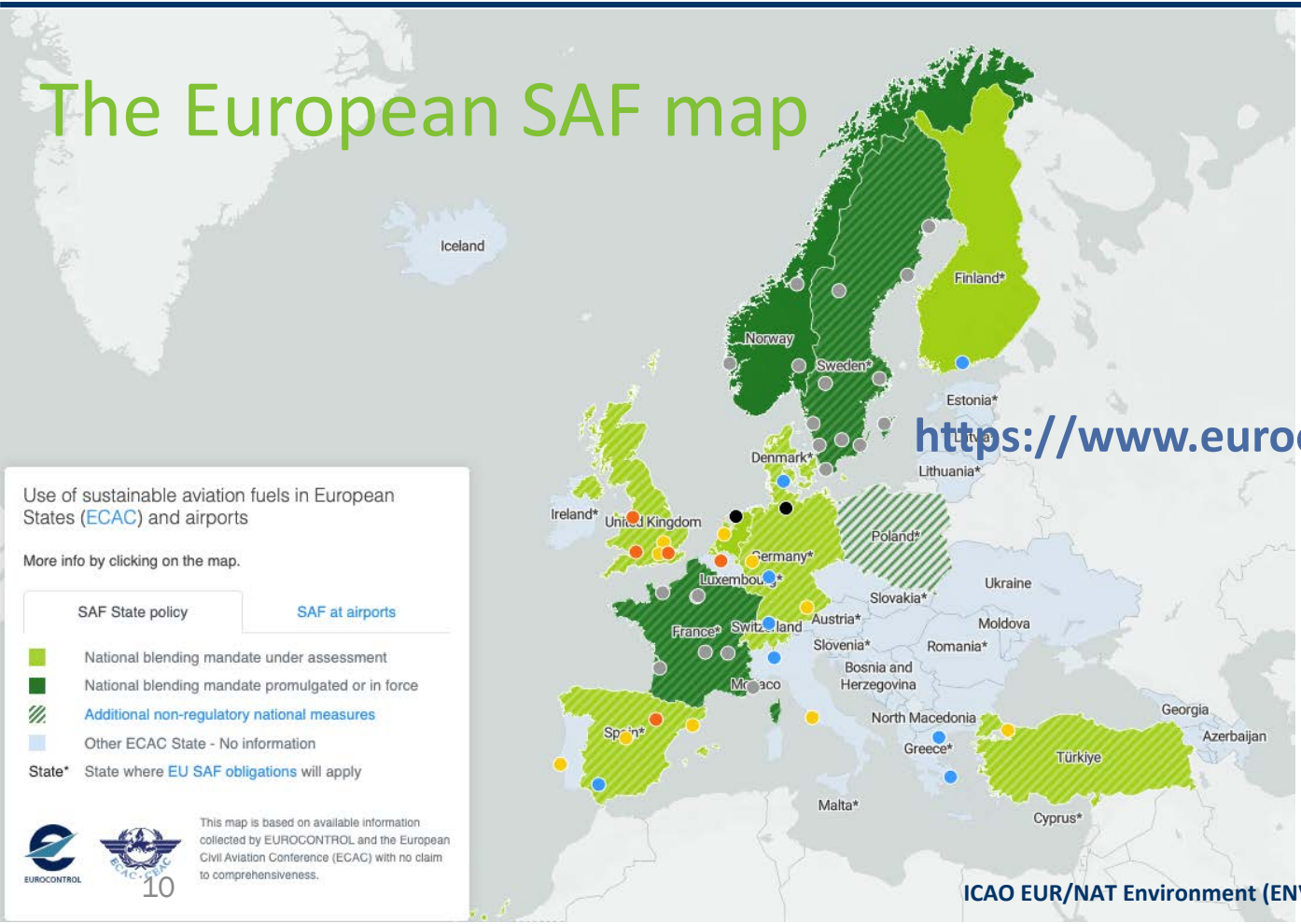
The European SAF map



https://www.eurocontrol.int/shared/saf/

EUROCONTROL

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Feedstock and industrial potentials in Europe

- **SAF can be produced from many renewable biomass feedstocks** and **renewable electricity** sources: Such flexibility provides **opportunities to States to identify feedstock and technology potentials** in their territories which could generate economic and social **opportunities**
- The two main industrial enablers are the availability of
  - **biomass feedstocks**, especially in the short and mid-terms,
  - and **renewable electricity** in the longer run.

Feedstock and industrial potentials in Europe

- **Sustainable biomass feedstocks**
  - **agricultural**, such as energy crops whose primary target is the production of energy
  - **forestry** and forestry residues
  - and **non-recyclable waste**, including for example used cooking oil, or part of municipal solid waste


Pic: Jeremy Bishop


Pic: Tomasz Zajaczkowski


Pic: Katie Rodriguez

Sustainable biomass feedstock potentials

- **Opportunities and challenges**

	Opportunities	Challenges
Agriculture	New machinery Efficient crop management practices Precision farming New varieties better adapted to local agroecological conditions. Improved knowledge through smart applications and increased numbers of young farmers and entrepreneurs	Pressure to develop agricultural land for environmental benefits such as carbon storage, biodiversity, etc., Land degradation from soil erosion, nutrient depletion and salinisation, etc.
Forestry	There is a large untapped potential of biomass from forestry. According to Lindner et al. [37] the biggest potentials can be found in Germany, Sweden, France, and Finland. In addition, especially in Southern and Western Europe forest utilization rates are low and in half of the EU countries less than two thirds of annual increment has been harvested [38] [39]. The potential could be further extended by developing technologies to access difficult terrains. Such terrains include steep slopes (especially in Central and Southern Europe) and peatlands (especially in Northern Europe). Digitalization and big data provide opportunities to radical innovations in biomass supply and logistics.	Climate change poses challenges to the whole European forestry. In Southern Europe droughts will be more common reducing growth and increasing risk for fires. In Northern Europe, on one hand, the increased temperatures will increase growth, but on the other hand the risk of natural damages will increase and the conditions for logging and transport deteriorate.
Biowastes	Increase awareness for biowastes collection among the public and especially in the young generation. Improve waste collection schemes across all Member States Use modern industrial separation technologies for maximising organic waste yield out of mixed waste streams.	Rising awareness for waste reduction and increase of recycling rates are expected to reduce biowaste availability at source.

Feedstock and industrial potentials in Europe

- **Renewable electricity**
  - Expected to play a key role in the decarbonisation of aviation **in the long-run**:
    - **to produce hydrogen** and hydrogen-derived fuels as aviation fuel
    - or **to directly power** hybrid/electric aircraft
  - But **in the mid-term** is **fundamental to produce synthetic aviation fuels** (PtL, e-fuels…)
    - Need big amount of renewable electricity to be produced. waste

Pic: Tom Arran

Industrial potential capacity and scale-up needs

- **There are different levels of industrial maturity for the available technologies**
  - Current European potential SAF capacity is based on the **Hydro-processed Esters and Fatty Acid (HEFA)** technology
  - **Co-processing biomass oils at existing fossil refineries** is also being developed as a rapid route to producing SAF at scale
  - There are multiple projects under development in Europe using **Fischer-Tropsch** and **alcohol to jet** to process Municipal Solid Waste or industrial waste gases
  - and **additional new pathways still under certification** process

Industrial potential capacity and scale-up needs

- **Some key references** (from CONCAWE analysis):
  - On average it takes about 2-2,5 years to build a First-of-a-Kind advanced biofuel plant
  - 6 months to 2 years to complete its commission once construction is completed
  - It takes about 10-20 years to bring a technology from the lab scale to First-of-a-Kind status for advanced biofuel technologies

Pic: Paul Teysen

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ICAO SAF Rules of Thumb: Estimating costs, investments, and production potential

- Available at: https://www.icao.int/environmental-protection/Pages/SAF_RULESOFTHUMB.aspx

  - ICAO CAEP experts developed a set of "Rules of Thumb" for sustainable aviation fuel (SAF) that could be utilized **to make order of magnitude estimations related to SAF costs, investment needs and production potential** that could inform policymakers and project developers.

  - The Rules of Thumb provide the impact of **feedstock cost**, **fuel yield**, **facility scale** (total distillate and SAF), **total capital investment** (TCI) and **minimum selling price** (MSP) for pioneer facility and further plants.

ICAO SAF Rules of Thumb

Summary Table 1 - Feedstock Information

Technology, feedstock type and price, yield, total annual distillate scale, annual SAF production for both n^{th} and pioneer facilities.

Processing Technology	Feedstock	Yield (ton distillate/ton feedstock)	Feedstock Price	Total Capacity (million L/year)		SAF production (million L/yearr)	
				n^{th}	pioneer	n^{th}	pioneer
FT*	MSW	0.31	$30/ton	500	100	200	40
FT*	forest residues	0.18	$125/ton	400	100	160	40
FT*	agricultural residues	0.14	$110/ton	300	100	120	40
ATJ	ethanol	0.60	$0.41/L	1000	100	700	70
ATJ	isobutanol-low	0.75	$0.89/L	1000	100	700	70
ATJ	isobutanol-high	0.75	$1.20/L	1000	100	700	70
HEFA	FOGs	0.83	$580/ton	1000	-	550	-
HEFA	soybean oil***	0.83	$809/ton	1000	-	550	-
FT	CO2 from Direct Air Capture (DAC) , H2	0.24	$300/t, $6/kg	1000	-	200	-
FT	waste CO_2, H_2	0.24	$300/t, $6/kg	1000	-	200	-
Pyrolysis**	forest residues	0.23	$125/ton	400	100	180	40
Pyrolysis**	agricultural residues	0.21	$110/ton	400	100	180	40

*feedstock price is for pre-processed feedstock

**pyrolysis ASTM approval is pending.

***2013-2019 average price of soybean and canola oils,

ICAO SAF Rules of Thumb

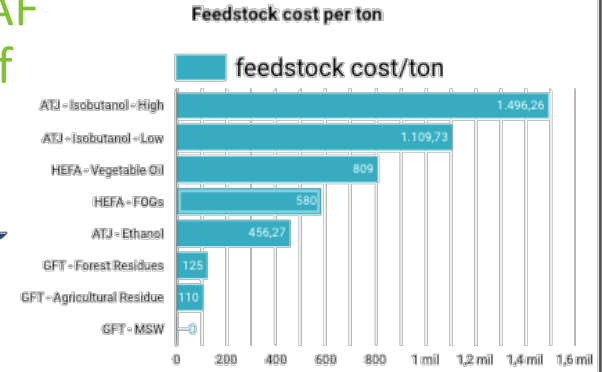
Summary Table 2 - SAF facilities information

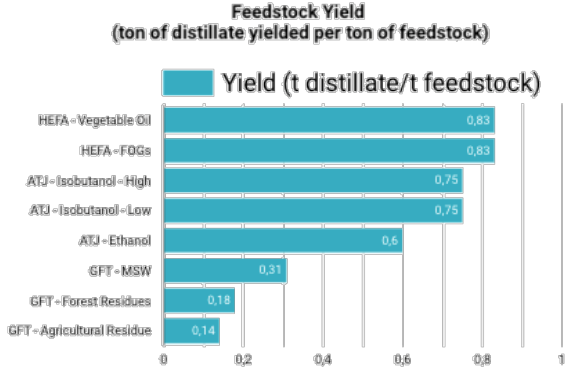
Total capital investment (TCI), capital cost, and minimum selling price (MSP) for n^{th} and pioneer facilities for each pathway.

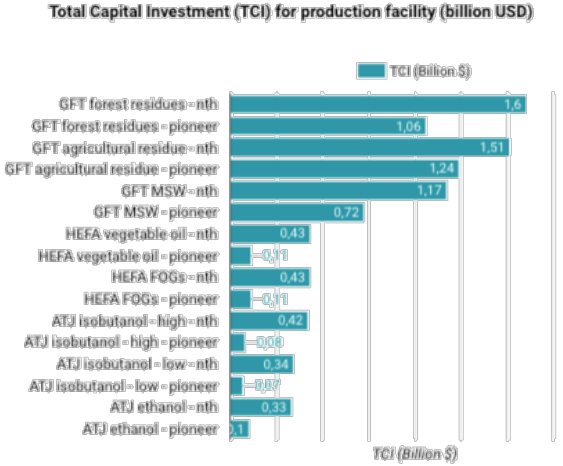
Processing Technology	Feedstock	TCI (million $)		Capital Cost ($/L total distillate)		MSP ($/L)	
		n^{th}	pioneer	n^{th}	pioneer	n^{th}	pioneer
FT*	MSW	1428	813	2.9	8.1	0.9	2.1
FT*	forest residues	1618	1088	4.0	10.9	1.7	3.3
FT*	agricultural residues	1509	1267	5.0	12.7	2.0	3.8
ATJ	ethanol**	328	117	0.3	1.2	0.9	1.1
ATJ	ethanol, agricultural residues	581	170	0.6	1.7	2.2	2.5
ATJ	isobutanol-low**	332	94	0.3	0.9	1.3	1.5
ATJ	isobutanol-high**	410	110	0.4	1.1	1.7	1.9
HEFA	FOGs	448	-	0.4	-	0.8	-
HEFA	vegetable oil	456	-	0.5	-	1.0	-
FT	DAC CO_2, H_2	3366	-	3.4	-	4.4	-
FT	waste CO_2, H_2	3209	-	3.2	-	3.5	-
Pyrolysis***	forest residues	1038	594	2.6	5.9	1.3	2.1
Pyrolysis***	agricultural residues	1084	619	2.7	6.2	1.3	2.2

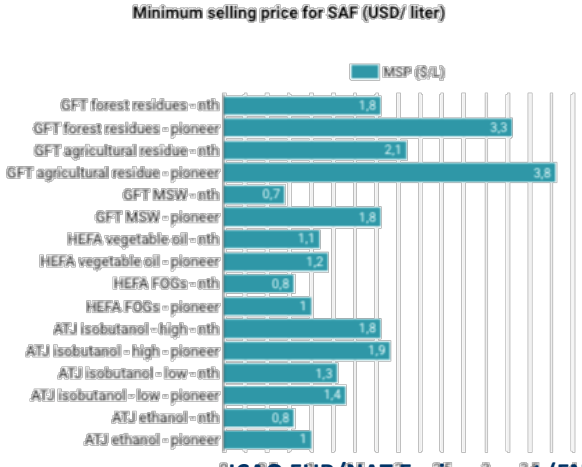
*feedstock price is for pre-processed feedstock,
**alcohol feedstock is corn-based,
***pyrolysis ASTM approval is pending.

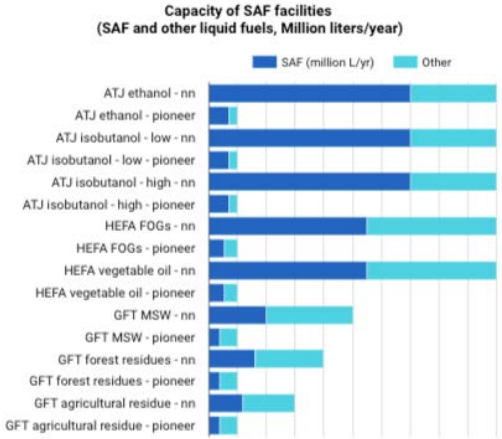
ICAO SAF Rules of Thumb











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For more information

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