

# PROSPECTS FOR PYROLYSIS OIL IN AVIATION

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**Flying is essential for economies globally**

**Aviation currently accounts for 3% of global emissions**

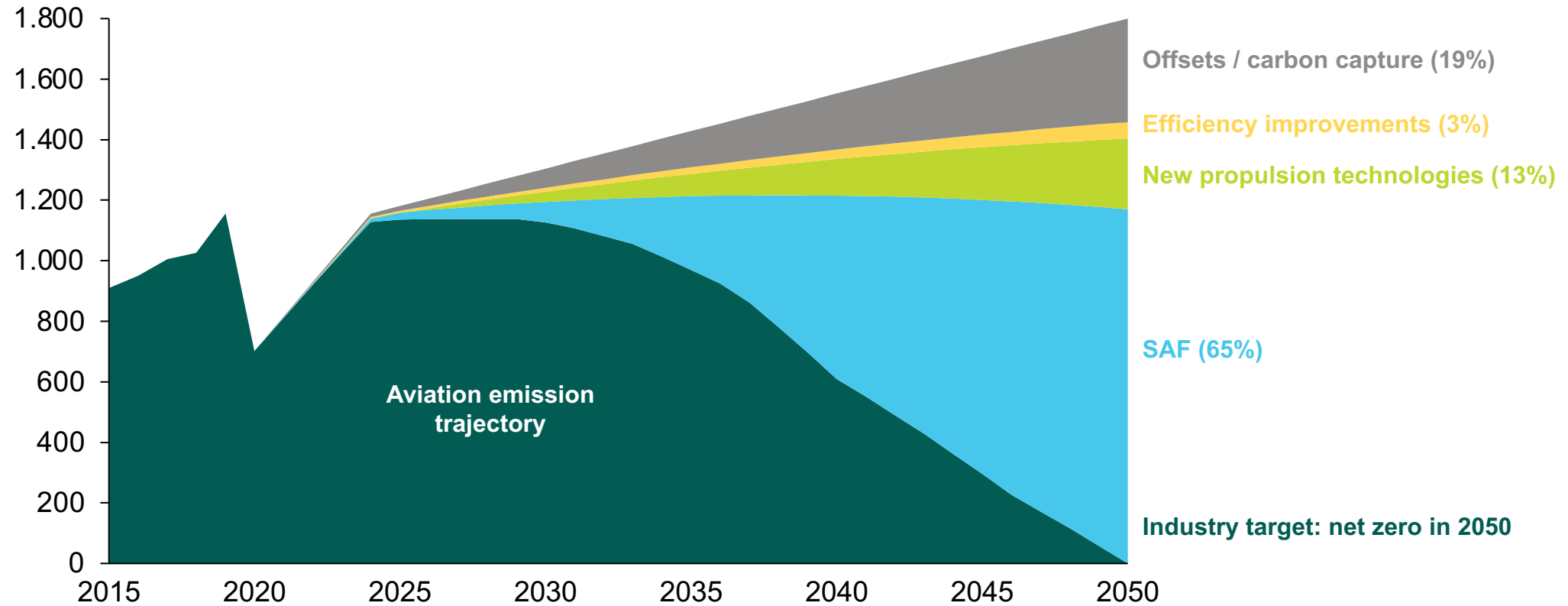
**With expected sector growth that is forecasted to become >20% in 2050**



# THE AVIATION INDUSTRY HAS COMMITTED TO NET ZERO IN 2050

## Global aviation emissions (Mt CO<sub>2</sub>)

Based on business-as-usual trajectory of IATA\*



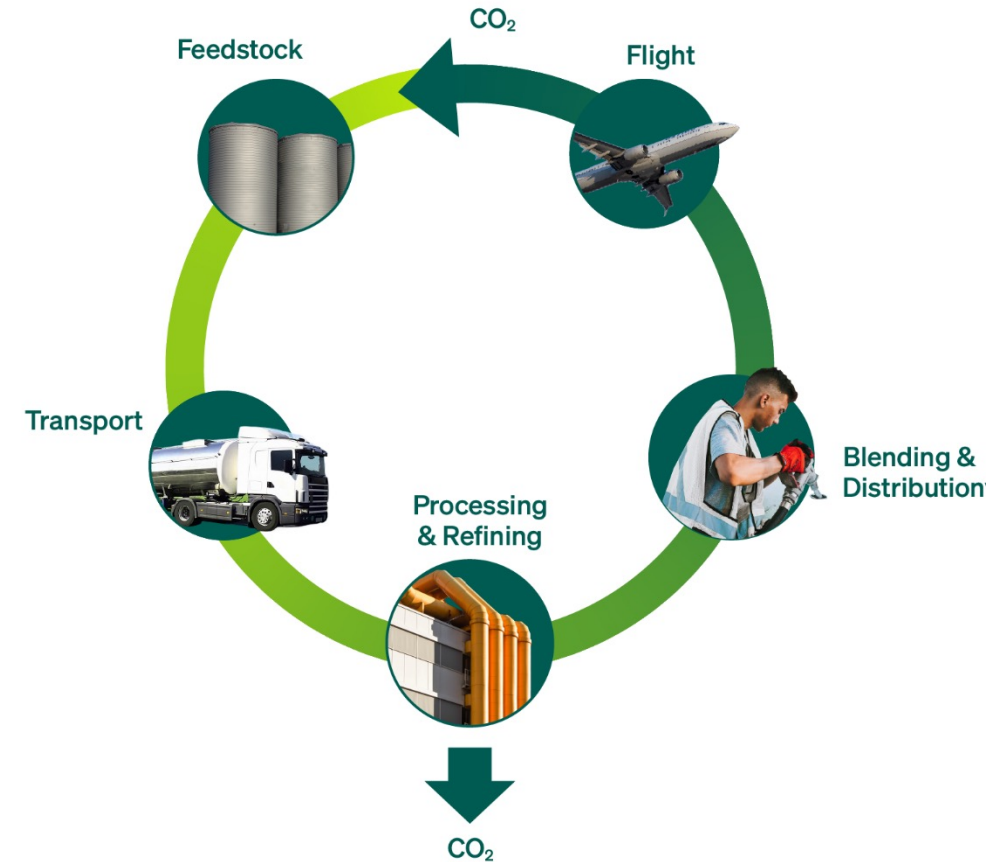


**Sustainable aviation fuel (SAF) is the only way to significantly reduce aviation emissions in the foreseeable future**

- ✓ **SAF meets all performance and safety requirements**
- ✓ **SAF does not require infrastructure and aircraft adaptations**
- ✓ **Proven at commercial scale: 370,000 flights and counting**
- ✓ **Various production pathways ready for deployment**
- ✓ **SAF can reduce life-cycle CO<sub>2</sub> emissions up to 100%**

# SAF HAS THE POTENTIAL TO REDUCE EMISSIONS BY UP TO 100%

- SAF can be produced from a wide range of renewable feedstocks including agricultural waste, biomass residue, industrial flue gases and pure CO<sub>2</sub>
- SAF can reduce greenhouse gas emissions by up to 100%<sup>1</sup>, depending on the production set-up
- SAF also reduces emissions of particulate matter (by up to 90%) and sulphur (by up to 100%)
- The production context matters: SAF producers should ensure they avoid (in)direct land use change, do not compete with food supply, or do not cause adverse social or economic impacts



1. By combining SAF production with carbon capture and storage, it is technically possible to move beyond 100% greenhouse gas reduction.



# WE ARE SKYNRG



We are a SAF capacity developer



We supply SAF to airlines



We provide SAF solutions for corporate and individual travelers



We do not compromise on sustainability





# SUSTAINABILITY IS AT THE CORE OF WHAT WE DO

We continuously strive to produce and supply **the most sustainable aviation fuel**, which follows the “do no harm, do more good” principle



Our supply chains are **fully RSB and CORSIA certified**. We do not touch feedstocks competing with food and feed applications



We have installed an **independent Sustainability Boards** of leading NGOs and scientists, to advise us on feedstocks and our production strategy

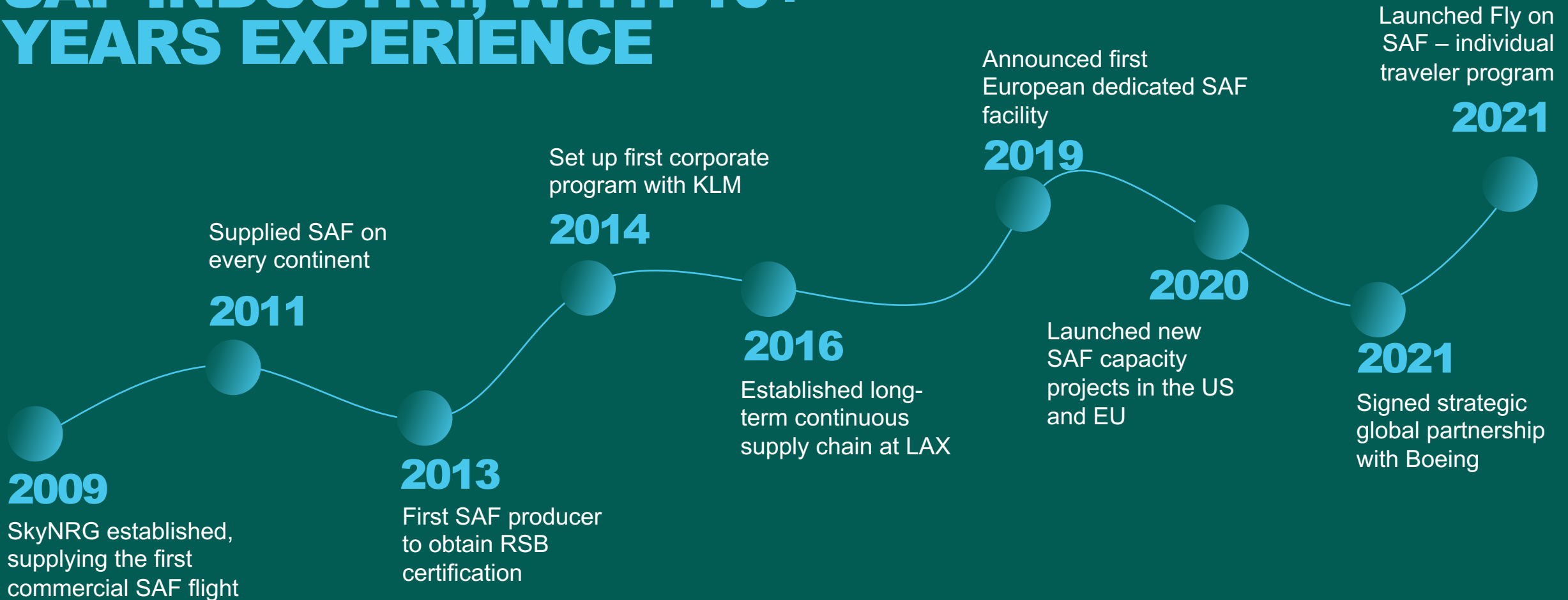


We are **B Corp™ certified** to further strengthen our sustainability governance for both the services we provide and our internal procedures



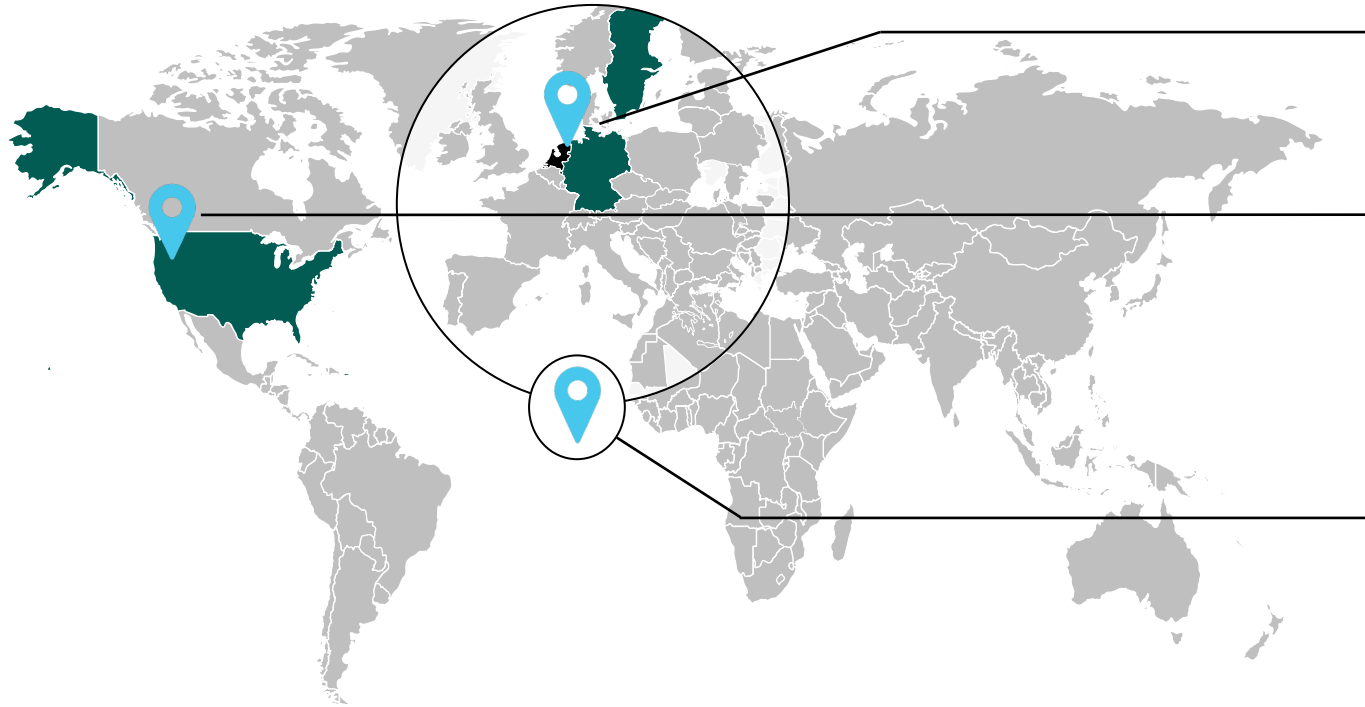
We have built a **global NGO network** to keep informed about regional specificities

# SKYNRG HAS BUILT A LEADING POSITION IN THE SAF INDUSTRY, WITH 10+ YEARS EXPERIENCE





# WE HAVE A DIVERSIFIED PIPELINE OF SAF CAPACITY PROJECTS IN VARIOUS STAGES OF DEVELOPMENT



**First capacity project – in development**

SkyNRG-Delfzijl ('DSL-01'), HEFA technology. 100 kt SAF output

**First US Scaling Hub – in development**

SkyNRG PNW, AtJ technology. ~90 kt SAF/RD<sup>2</sup> output

**First EU Scaling Hub ('EU-01') – in early-stage development**

SkyNRG AMS ('Synkero'), PtL technology.

Germany, PtL technology.

Sweden, FT technology.

# GOVERNMENT MANDATES AND VOLUNTARY DEMAND SET A CLEAR DEMAND SIGNAL FOR SAF

SAF demand will be driven by policies



The EU just announced a SAF blending mandate starting with 2% in 2025 and growing to 63% in 2050



In addition, various European countries announced more ambitious SAF targets



The United States already incentivize the use of SAF; The Biden administration targets 100% SAF use in 2050



The global CO<sub>2</sub> framework CORSIA is expected to cost airlines 3-12 B\$ by 2030<sup>1</sup>

... and voluntary uptake

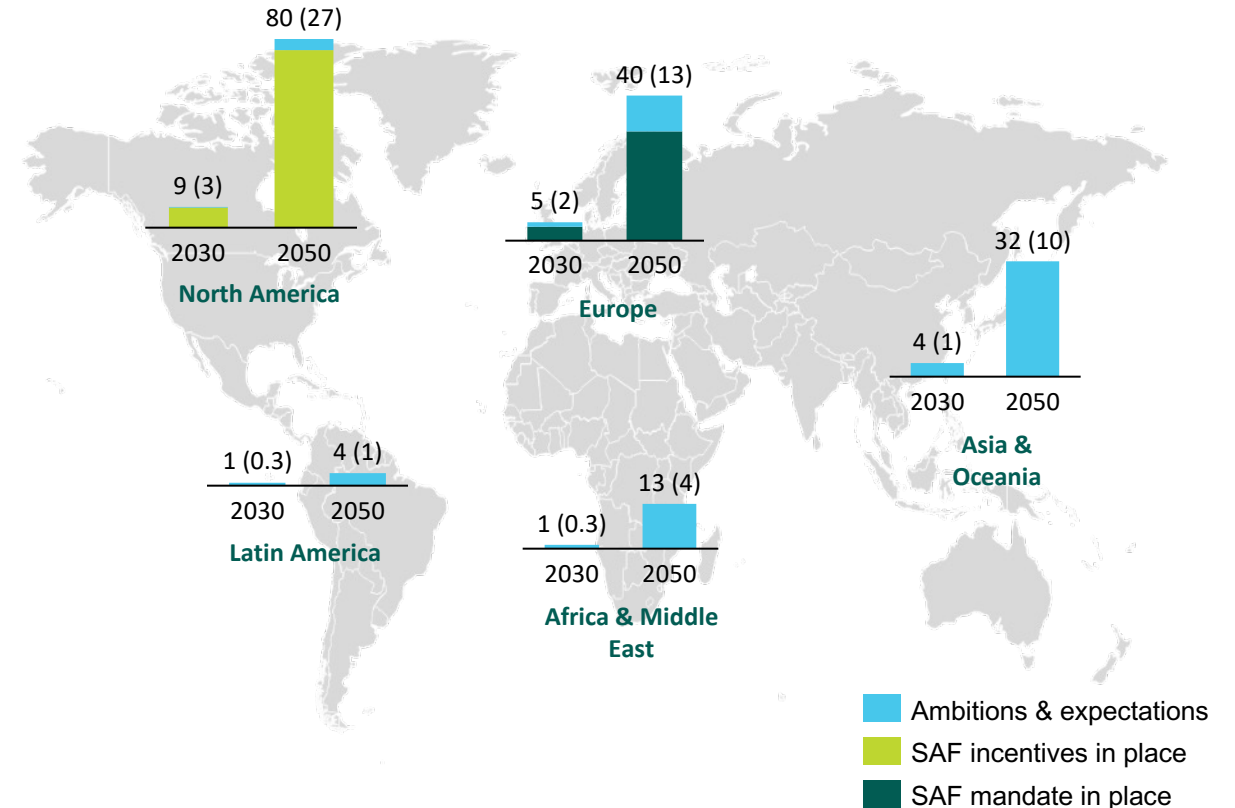


There are strong demand signals from corporates, airlines and cargo carriers which are starting to get backed by long-term offtakes, including, e.g.:

- DHL Express: 30% of fuel uptake by 2030
- Delta Airlines: 10% of fuel uptake by 2030
- IAG: 10% of fuel uptake by 2030

SAF demand to increase to 19 Mt (6 Bgal) in 2030 to ~170 Mt (60 Bgal) in 2050

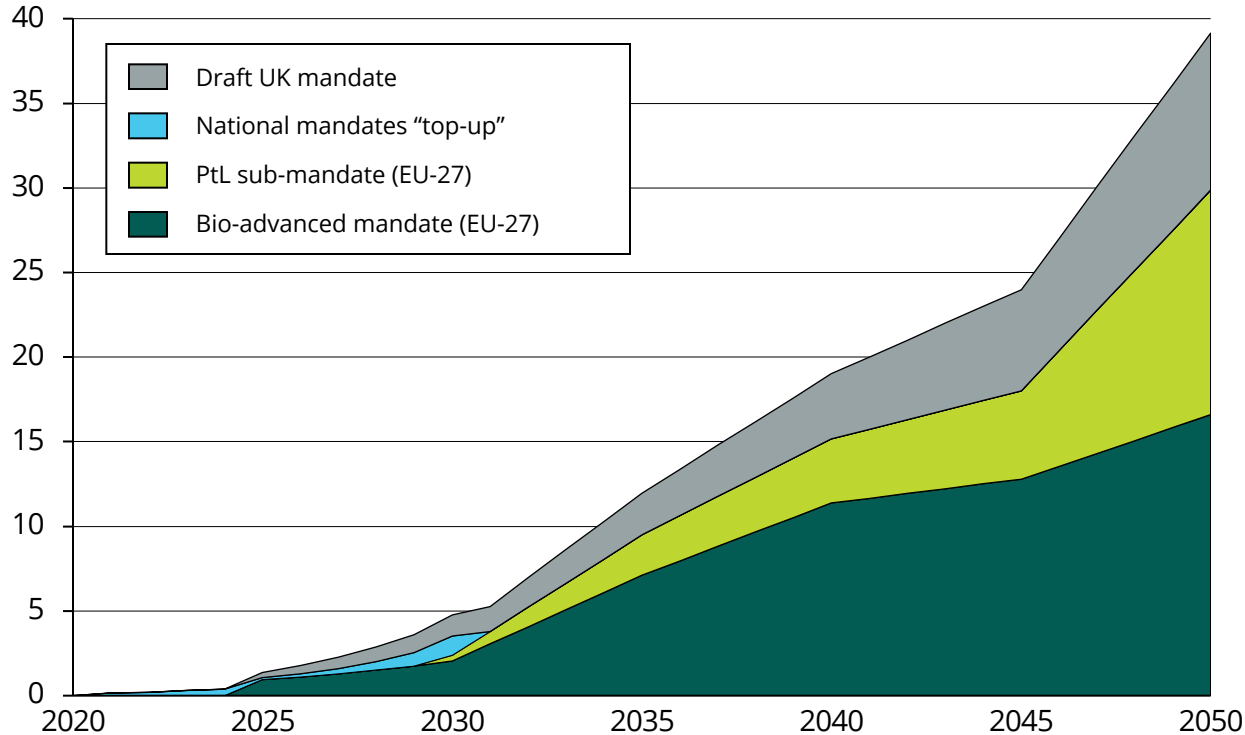
NB. Graphs denote SAF demand in million tonnes (Bgal in between brackets)



1. Under the CORSIA framework, airlines need to offset emissions to achieve carbon-neutral growth. Source: ATAG Waypoint 2050 (2020), EU ReFuel package (2021), US SAF Grand Challenge (2021), Argus (2020), McKinsey & Company (n.d.), CORSIA (2018), SkyNRG market outlook on SAF (2021), SkyNRG analysis

# INSTALLED AND EXPECTED MANDATES IN THE EU AND THE UK COULD RESULT IN A SAF DEMAND IN EUROPE OF ~40 MT IN 2050

## SAF mandates in Europe, incl. UK (Mt SAF)



**Please note:** Graph does not include voluntary SAF commitments from airlines and corporates

## Key takeaways

- The ReFuelEU mandate for SAF increases steeply from 2.4 Mt in 2030 to 15.2 Mt in 2040.
- The mandate for PtL SAF accelerates after 2045 to 13.3 Mt in 2050.
- Total anticipated mandated volumes are 1 Mt in 2025, 3.5 Mt in 2030 and 30 Mt in 2050.
- The UK is currently considering installing a SAF mandate that would start at 10% in 2030,<sup>1</sup> increasing to 75% by 2050 resulting in 9.3 Mt SAF demand.

## Note

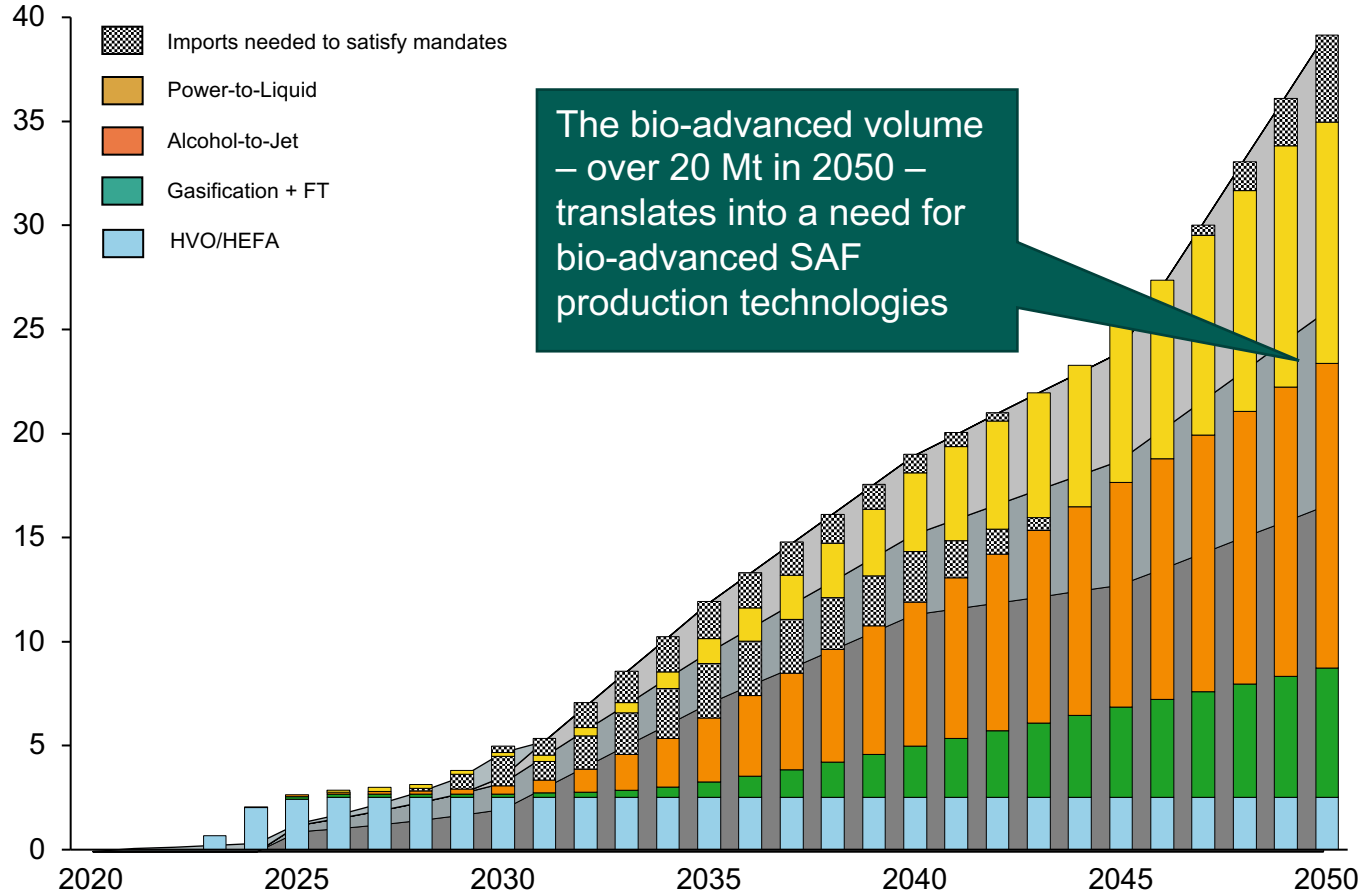
- As of September 2022, the negotiations (between EC, EP, and ministries) on ReFuelEU are ongoing which could still see the minimum percentages significantly changed by the end of 2022.<sup>2</sup>
- The European Parliament has proposed increasing the target for the overall mandate to 85% by 2050, with the synthetic aviation fuel sub-mandate (PtL) responsible for the increase.

<sup>1</sup> Based on: Department for Transport, Sustainable Aviation Fuel Mandate - A consultation on reducing the greenhouse gas emissions of aviation fuels in the UK, Scenario E - Early SAF breakthrough ([link](#))

<sup>2</sup> Source: [EURACTIV](#) (2022)

# LONG-TERM GROWTH IN EUROPEAN SAF CAPACITY SHOULD COME FROM BIO-ADVANCED SAF AND POWER-TO-LIQUIDS

## European SAF supply outlook up to 2050 (Mt)



## Key takeaways

- About 400 SAF plants will be required to fulfil the expected European mandates by 2050 (vs. ~25 EU plants currently announced).
- Pathways depending on (ligno-)cellulosic wastes & residues will become essential to achieve mandated volumes.
- Rapid deployment of new technologies (AtJ, FT, pyrolysis) and feedstock mobilization is required to supply mandated volumes post 2030.
- Imports are needed to achieve mandated volumes.

## Key boundary conditions in this analysis

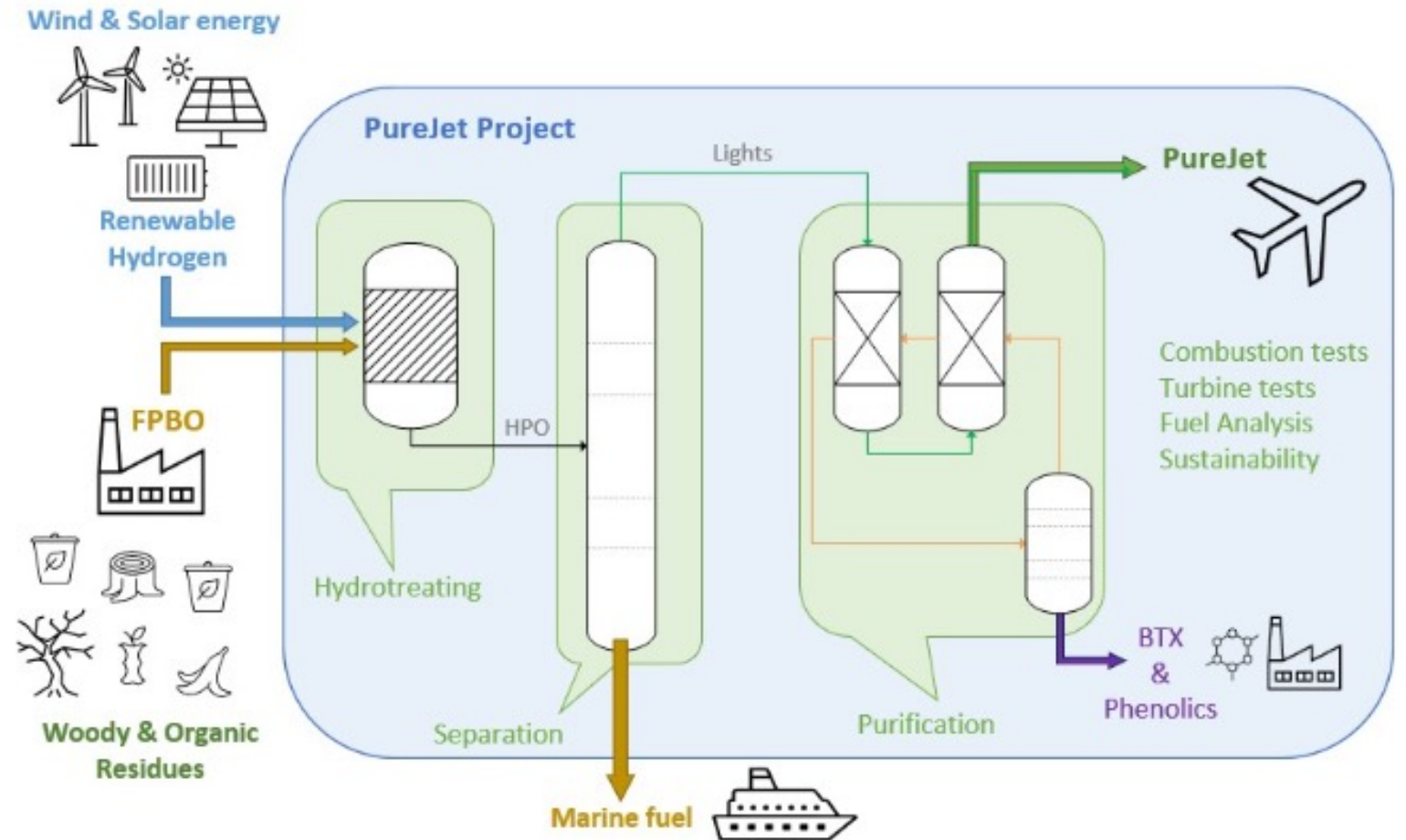
- Upscaling of plants is limited by global feedstock availability in case of HEFA, and EU feedstock availability for other pathways.
- A maximum of 10 bio-advanced SAF plants are realized per year, with a maximum of 10 for PtL.
- Imports amount to a maximum of 30% of the total SAF supply.
- Product slates of FT and HEFA technologies are not fully jet-optimized due to expected fuel demand from road sector.
- UK mandate assumed at same PtL/bio split as EU mandate.
- See Methodological Annex for detailed methodology.

# PUREJET IS AN EXAMPLE OF A R&D PROJECT WITH GREAT POTENTIAL TO PROVIDE LARGE VOLUMES OF SAF TO THE INDUSTRY

- PureJet aims to produce a drop-in aviation fuel that achieves over 70% GHG emission reduction.
- The PureJet product is rich in **cyclo-alkanes**, which has the potential to replace aromatics in jet fuel leading to a high-performing SAF product that reduces the disadvantages related to aromatics, such as: particulate matter emissions, reduced air quality around airports, and non-CO2 global warming effects related to contrail formation.

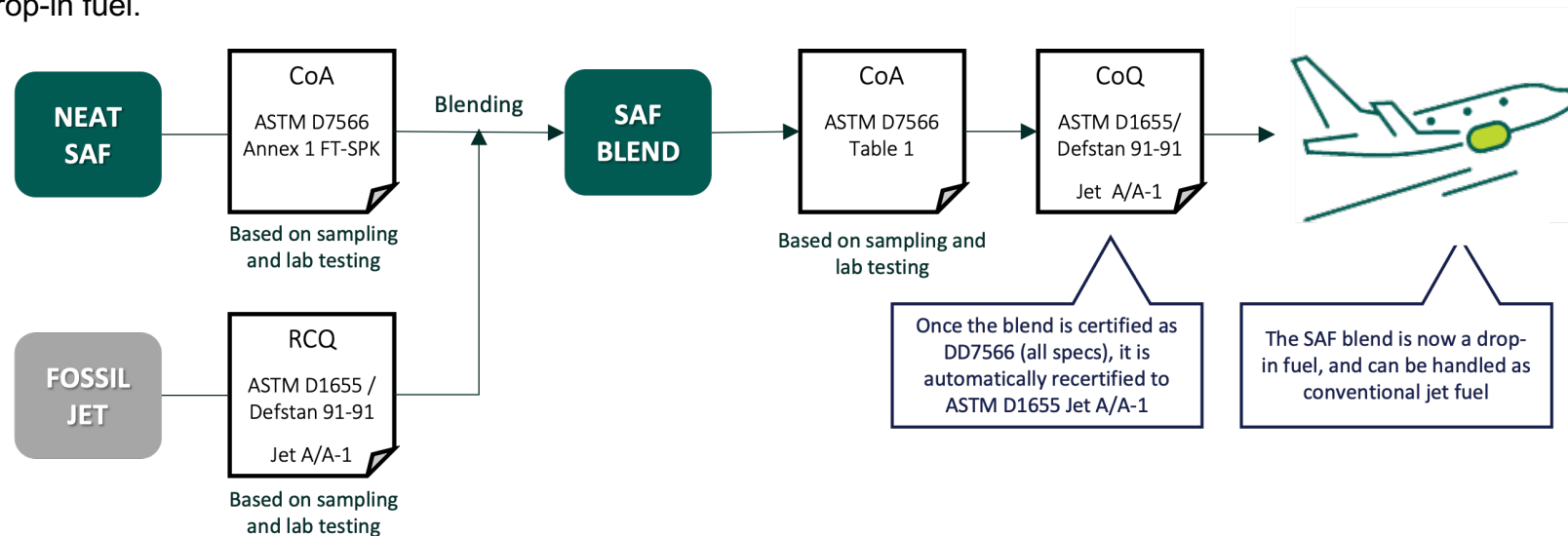
## Challenge:

- Pyrolysis jet fuel is not ASTM certified and thus not allowed for use in commercial aviation yet
- ASTM certification of new SAF production routes is a costly and time-consuming process.



# CHALLENGE OF PYROLYSIS JET IS THAT NEW SAF PRODUCTION PATHWAYS REQUIRE ASTM CERTIFICATION WHICH IS A COSTLY PROCESS

- ▶ **ASTM** (American Society for Testing and Materials) is a society that creates worldwide accepted standards for materials and fuels. For conventional jet fuel this standard is ASTM D1655<sup>1</sup>.
- ▶ ASTM developed a special standard for alternative jet fuel: **D7566** *Specification for Aviation Turbine Fuel containing synthesized hydrocarbons*.
- ▶ The compliancy of SAF is governed in D7566 via the following principles:
  1. **Production:** every new SAF production pathway requires inclusion in ASTM D7566. This D7566 inclusion is requested following the D4054 evaluation procedure leading to addition of a new annex added to the standard upon approval. The D4054 evaluation procedure takes approximately 1.5 to 5.5 years to complete, depending on the production route and SAF composition and may consume large volumes of jet fuel.
  2. **Blending:** neat SAF must be certified according to the D7566 specification requirements as described in the corresponding annex, followed by blending with conventional jet fuel to meet the D7566 specifications for blends containing synthetic components before the fuel is recertified as a D1655 fuel and considered a drop-in fuel.

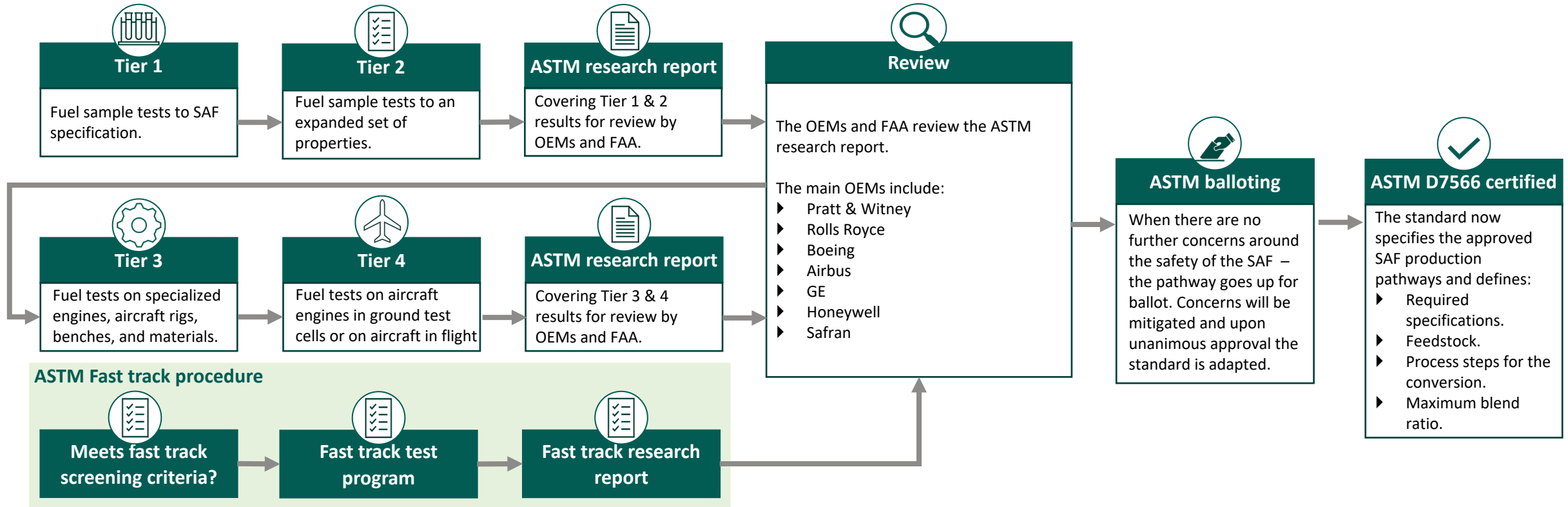


SkyNRG offers consulting work to request ASTM approval of SAF production pathways and inclusion in ASTM D7566 in collaboration with fuel producers.

<sup>1</sup> Many other specifications exist (such as DefStan of the United Kingdom's Ministry of Defence), but basic principle applies to all: every batch of fuel should always comply with the specifications of the applicable standard for that region.

# SAF PRODUCTION PATHWAYS ARE CERTIFIED VIA THE ASTM D4054 EVALUATION PROCEDURE

- ▶ ASTM D4054 evaluation procedure starts with extensive lab testing before the fuel is tested on specialized engines or on aircraft flights.
- ▶ Tier 1 + Tier 2 testing requires roughly 400L fuel, while Tier 3 + Tier 4 testing may consume up to 850 000 Liter.
- ▶ Approval of the Original Equipment Manufacturers (OEMs) and Federal Aviation Administration (FAA) is required before the new pathway will enter the ASTM balloting phase to achieve unanimous approval before inclusion in ASTM D7566.



**SKYNRG**

The logo consists of the word "SKYNRG" in a bold, black, sans-serif font. Below the text is a stylized graphic element: a horizontal line with a central drop shape. The drop is filled with a light blue gradient and has a white outline. The entire logo is centered on a dark blue background.