Flying Net Zero, safely

A decarbonisation roadmap of aviation

Nicolas JEULAND
Safran Innovation
CONCAWE Symposium 2026



~106,000 flights a day.
Not one is allowed to fail.

Decarbonising aviation means taking the carbon out of every one of them, without taking a single point out of the safety margin.

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Part 1

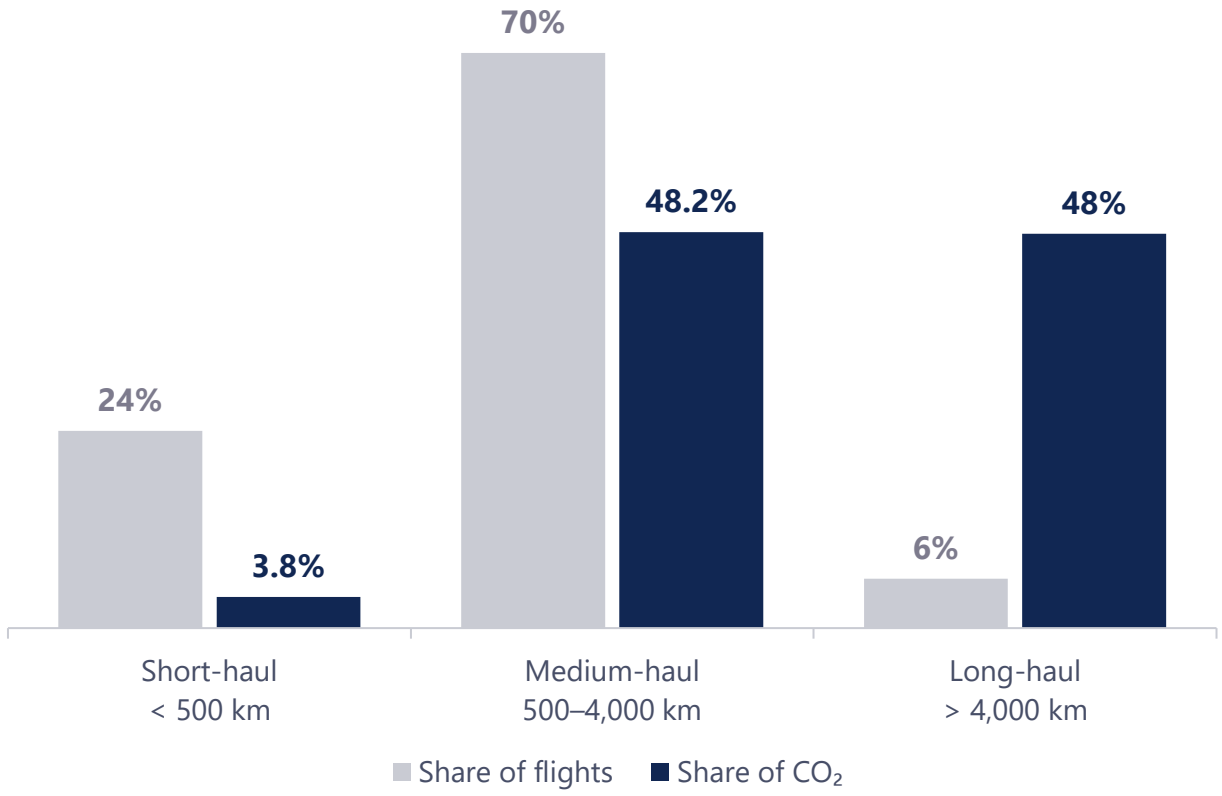
Why aviation is different

Five constraints that shape every decision: missions, time, maturity, weight and safety.

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One sector, three very different missions

European departures by flight distance, 2019



6% → **48%**

of flights — of CO_2 emissions

Long-haul flights carry over 40% of seat-km: there is no alternative mode.

Electrifying every flight under 500 km would address less than 4% of European aviation CO_2.

Half of the problem sits on long-haul, where only a dense liquid fuel can do the job for decades to come.

Source: EUROCONTROL Data Snapshot, CO_2 emissions by flight distance (2019 data). Medium-haul band derived by difference.

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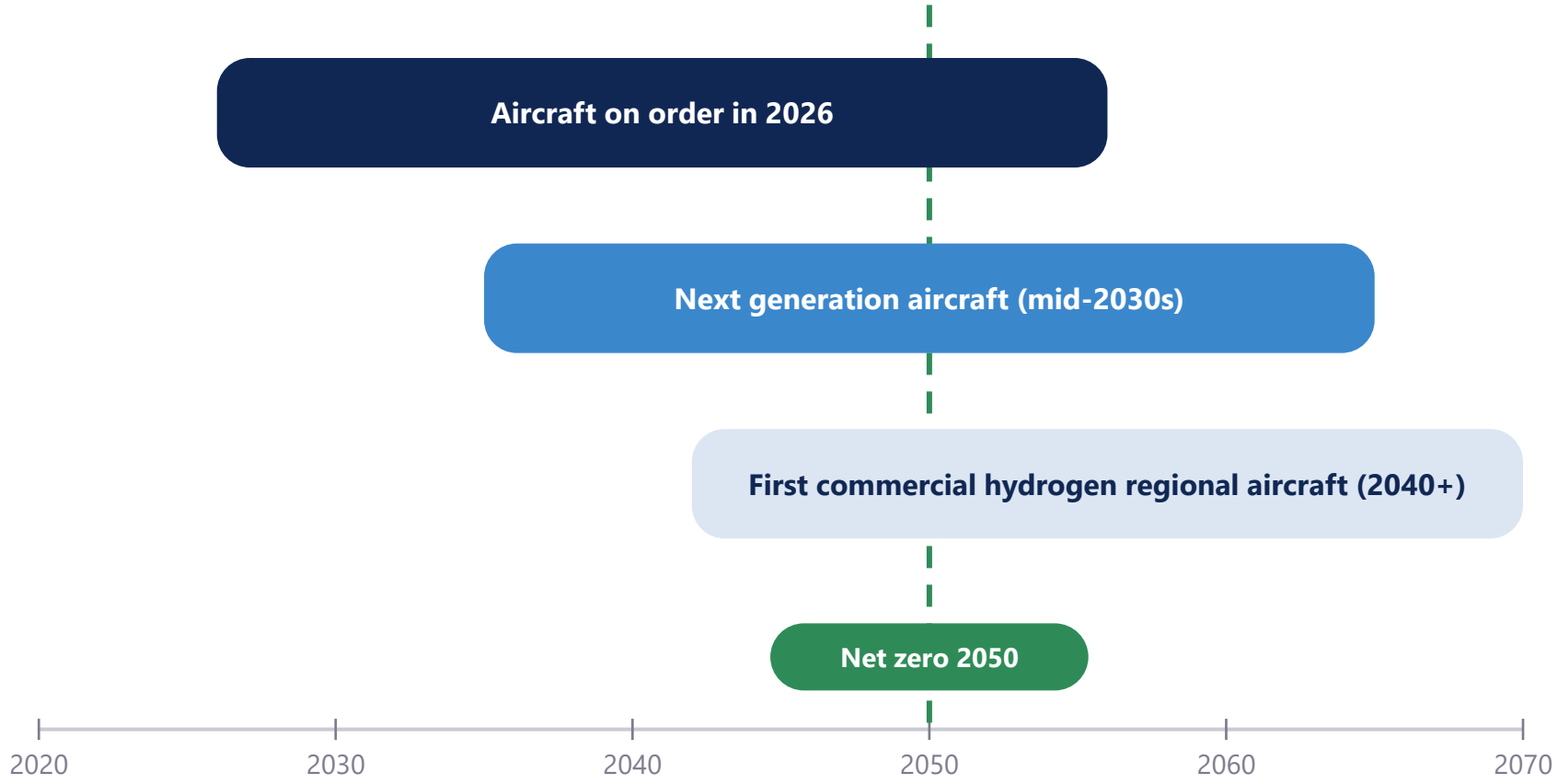
Aircraft fly for 20+years: the 2050 fleet is already here

~25

years of service for an airliner

About one third of the global fleet is latest-generation today.

A new engine generation arrives roughly every 15 to 20 years, then takes decades to spread across the fleet.



Consequence: most aircraft that will fly in 2050 are already in service or on order. To decarbonise them, we must decarbonise what goes into their tanks.

Sources: ATAG Waypoint 2050 (3rd edition, 2026); CFM International. Bars are illustrative service lives.

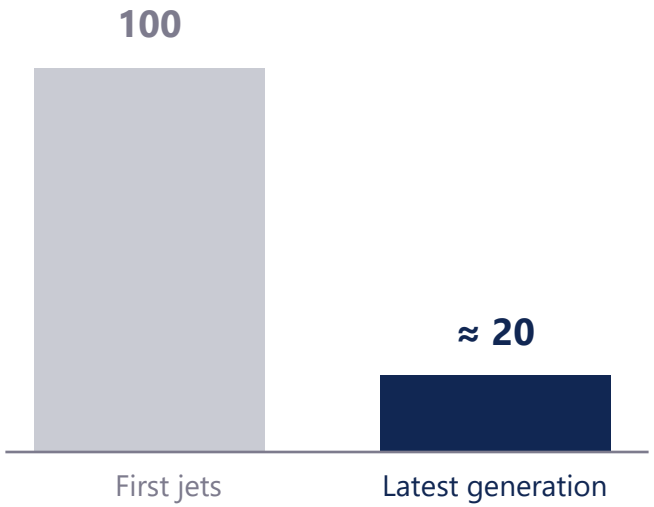
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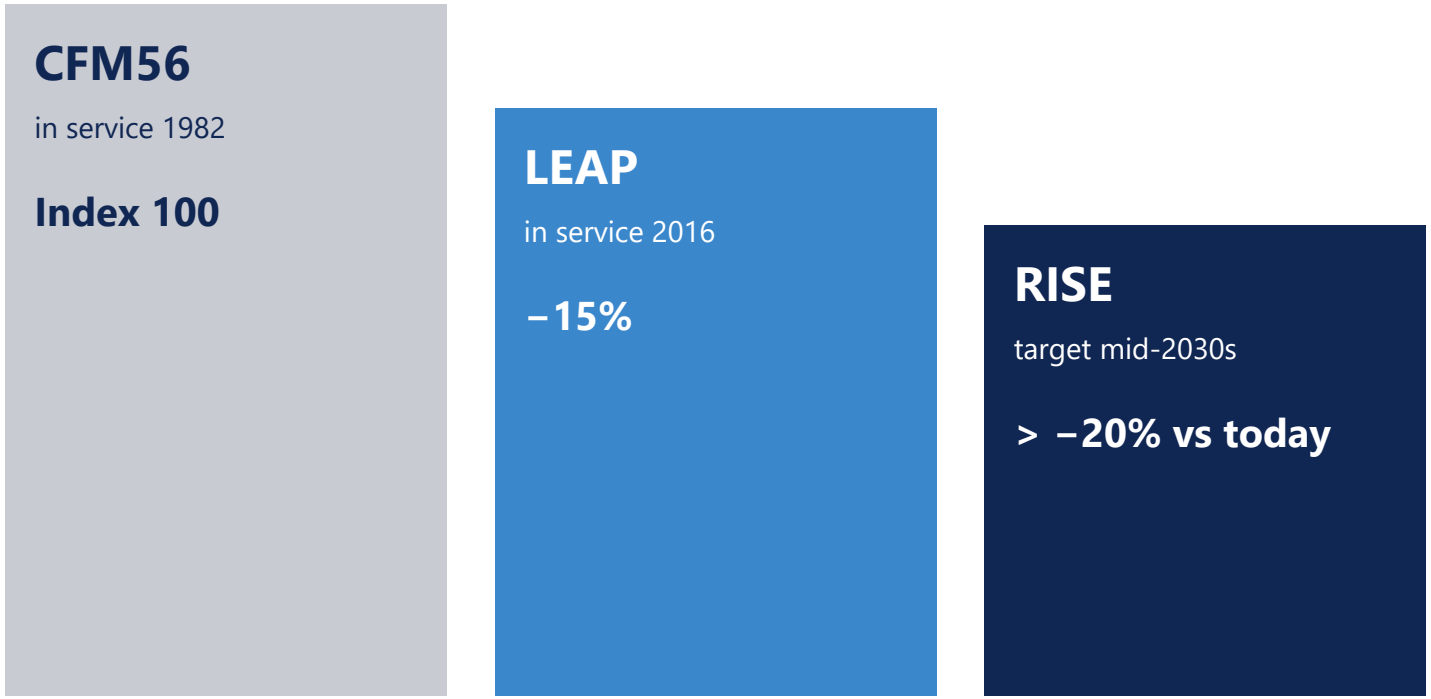
80% already achieved: the easy gains are behind us

−80%

fuel burned per passenger-km compared with the first jets of the 1950s–60s



Each new engine generation: 15 to 20% better, decades apart



Meanwhile, traffic grows ~3.8% a year (×2.7 by 2050). Efficiency alone cannot outrun growth.

Sources: ATAG; CFM International (LEAP vs CFM56, RISE target vs engines in service); ATAG Waypoint 2050, 2026 edition (traffic).

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Weight: every kilogram flies ~12,000 times

~12,000

flights in the life of a long-haul aircraft

1 kg saved on board is worth

≈ 4 t of fuel

≈ 13 t of CO_2 over its life

*Illustrative order of magnitude**

* *Breguet range equation: ~0.35 kg of fuel per extra kg carried on a 10,000 km flight, ~480 flights a year over 25 years, 3.16 kg CO_2 per kg of fuel..*

Every gram counts

Three airline cases

RULE OF THUMB
−1% aircraft weight
≈ −0.75% fuel burn



ANA · 2009

Ask passengers to use the restroom before boarding

WEIGHT REMOVED
≈ 64 kg per 150 passengers

ESTIMATED SAVING
4.2 t CO_2
per month
If half of passengers went before boarding. One-month trial on 42 flights.



UNITED AIRLINES · 2018

Print the inflight magazine on lighter paper

WEIGHT REMOVED
28 g per copy · ≈ 5 kg per flight

FUEL SAVED
170,000 gal
per year
≈ 640,000 L and $290,000 a year, about 1,600 t of CO_2 avoided.



UNITED AIRLINES · 2011

Replace pilots' paper manuals with iPads

WEIGHT REMOVED
≈ 16 kg per pilot flight bag

FUEL SAVED
326,000 gal
per year
11,000 iPads deployed, 3,208 t of CO_2 avoided each year.

Sources: ANA via CNN and TravelMole (Oct 2009); United via Los Angeles Times (Jan 2018); United Continental press release (23 Aug 2011); rule of thumb from Jefferies via CNBC (Jan 2026). Litre and CO_2 equivalents for the magazine case are our own conversions: 1 US gal = 3.785 L, jet fuel 0.8 kg/L, 3.16 kg CO_2 per kg of fuel burned.

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Safety: the one parameter that never moves

1 fatal accident in

5.6 million

flights (2021–2025 average, IATA)

A decade ago: 1 in 3.5 million. This record was built on standards, data and one fuel whose behaviour we know in every condition.

CFM engines alone: more than 1.4 billion flight hours on single-aisle aircraft.

Fuel specification / Fuel qualification / Fuel monitoring

ASTM, Def Stan, JIG…

Engine certification

EASA CS-E / FAA Part 33

Aircraft certification

EASA CS-25 / FAA Part 25

Operations & maintenance

airline procedures, airport fuel quality control

Change the energy, and every link of the chain must be demonstrated again.

Sources: IATA Annual Safety Report 2025; CFM International.

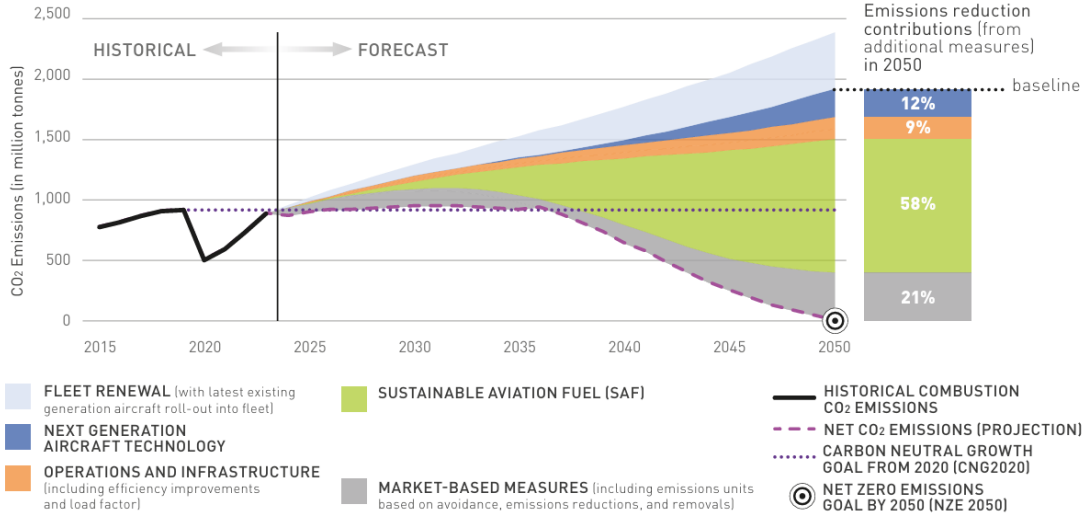
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Waypoint 2050: no silver bullet, four pillars

×2.7
passenger traffic, 2023 → 2050

430–500 Mt
of SAF a year needed by 2050 (scenario 1)



Atag Waypoint2050, 2026, scenario 1

Share of 2050 CO_2 reductions

New aircraft & engine technology — 12–21%

Operations & infrastructure — ~9%

Sustainable aviation fuels — 38–58%

Market-based measures & carbon removals — 19–32%

Solid bar: low end of the range; light bar: high end. Source: ATAG, Waypoint 2050, 3rd edition (January 2026).

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RISE: >20% less fuel



> 20%

lower fuel burn vs. engines in service today

Open Fan

A much larger, unducted fan: more air, less energy.

Compact core

Higher pressures and temperatures, advanced materials.

Hybrid-electric

Electrical machines embedded to optimise every phase.

Fuel-flexible

Designed for 100% SAF and compatible with hydrogen.

2021

Programme launch by CFM (Safran & GE Aerospace)

2024–26

Component tests: >1,000 h on the high-speed low-pressure turbine

~2030

Flight tests on the Airbus A380 flying laboratory

Mid-2030s

Target entry into service

Sources: CFM International, Airbus (Farnborough 2026 and earlier programme communications). RISE is a technology demonstration programme.

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Lighter everywhere: from fan blade to brake disc

Every kilogram removed is multiplied by ~12,000 flights. Safran works on weight across the whole aircraft.

3D-woven composite fan

Resin-transfer-moulded fan blades and fan case on LEAP: lighter than metal and highly durable.

Ceramic matrix composites

CMC parts in the hot section: a fraction of the weight of superalloys, able to run hotter.

Additive manufacturing

LEAP fuel nozzle printed in one piece instead of about twenty: around 25% lighter.

Carbon brakes

Carbon heat-sink brakes from Safran Landing Systems: much lighter than steel brakes.

More-electric aircraft

Lighter power generation, distribution and wiring from Safran Electrical & Power.

Cabin & seats

Lighter seats and cabin equipment: savings paid back on every single flight.

Weight is also a SAF lever: every kilogram saved is fuel that never has to be produced.

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SAF: the only lever that decarbonises the aircraft already flying

Provided every drop is fully compatible
with every aircraft, engine and fuel system.

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Drop-in or nothing: one fuel for the whole fleet

Feedstocks

waste oils & fats, residues, alcohols, CO_2 + H_2

Conversion

approved ASTM D7566 routes: HEFA, FT, ATJ, SIP, CHJ...

Blending

up to 50% with fossil kerosene today

Certification

as Jet A-1: ASTM D1655 / Def Stan 91-091

Any aircraft

same tanks, hydrants and engines

Aromatics ≥ 8%

Aromatics impact on nitrile seals of legacy fuel systems swell is only the upper part of the iceberg. Aromatic content is linked to hundreds of key fuel properties. Most SAF pathways contain almost none: the blend must supply them.

Every property counts

Density and energy content, lubricity, freezing point, thermal stability, water behaviour...: a fuel is judged on all of them at once.

Qualification takes years

ASTM D4054: tiered tests from the laboratory to rigs and engines, reviewed by engine and airframe manufacturers.

Next step: qualifying 100% drop-in SAF without splitting the fleet into "SAF-ready" and "legacy" aircraft.

Safran engines have already run on 100% SAF in ground and flight tests. Approved pathways listed are examples.

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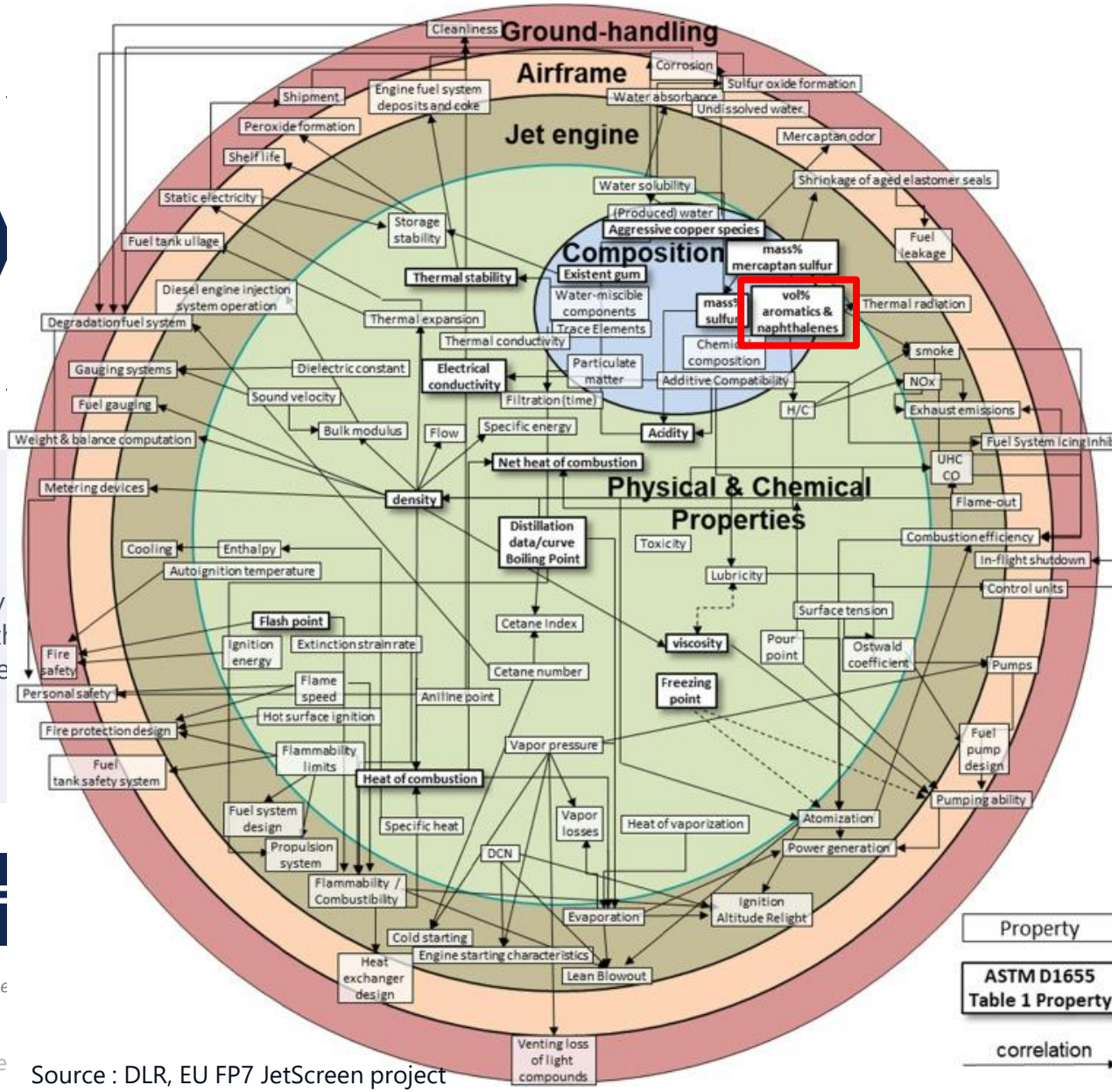
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Source : DLR, EU FP7 JetScreen project

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BA38, Heathrow 2008: a striking example of when fuel behaviour surprises

Beijing → London, ~10 h

Outside air down to −76 °C

Short final: thrust demanded

Fuel tanks

Fuel very cold after hours at cruise; normal dissolved water in it

→

Feed pipes

Ice slowly accretes on pipe walls at low cruise fuel flow

→

FOHE

On approach, released ice blocks the fuel-oil heat exchanger

→

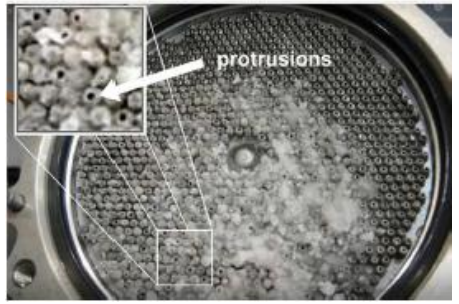
Both engines

Fuel flow restricted: thrust rolls back on both engines

Boeing 777 lands short of runway 27L. 152 on board, all survived.

Also: CX780, Hong Kong, 2010. Fuel contaminated at loading jammed the thrust control of both engines: landing at about 230 kt, no fatalities.





What it teaches us

1. **The fuel met its specification.** The hazard came from how ordinary dissolved water turned to ice at very low temperature.
2. **Water solubility rises with aromatic content.** Change the chemistry and you change the water and ice behaviour.
3. **Aromatics also keep legacy seals tight.** Low-aromatic SAF may form less ice, but also may induce higher free water when blended with conventional fuel in the aircraft tank: every property moves at once.
4. **The fix took years:** heat exchanger redesign, new procedures and certification requirements.

Fuel is a flight-critical component: its chemistry must be known, never assumed.

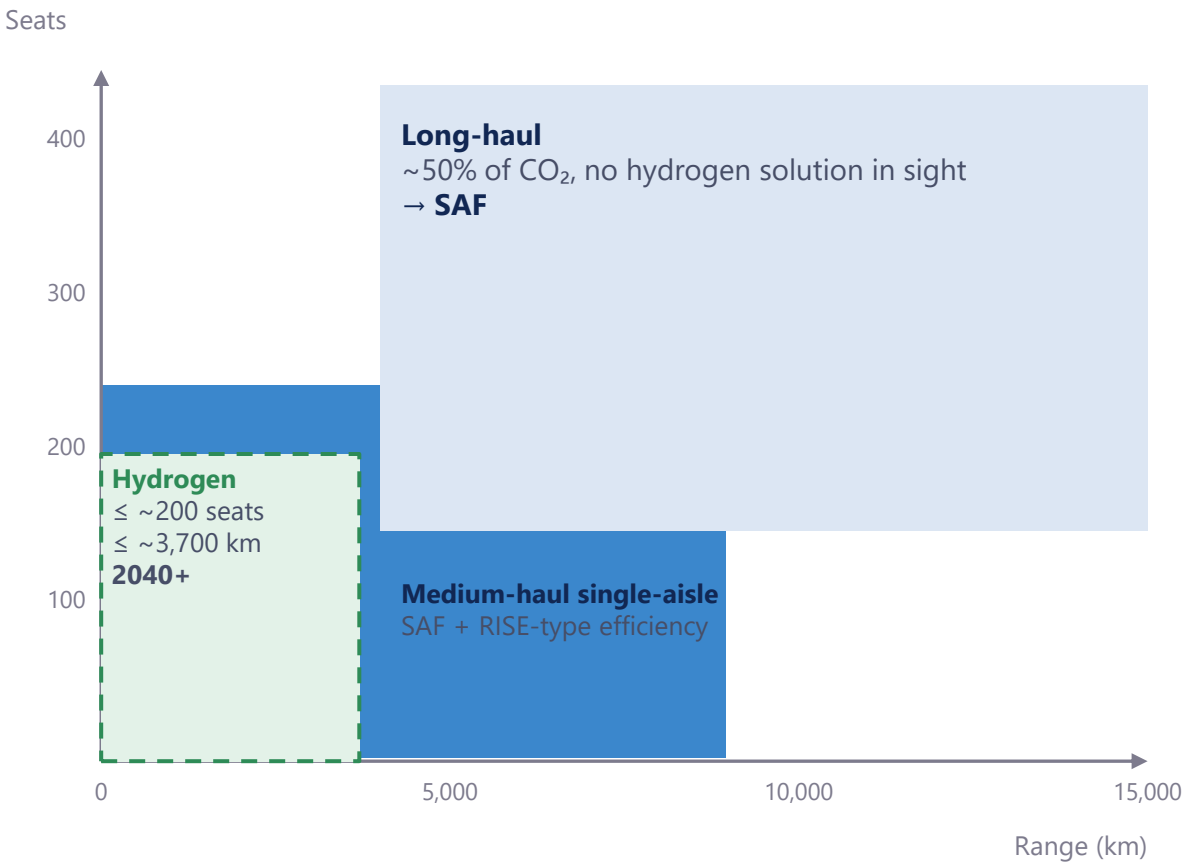
Sources: UK AAIB Aircraft Accident Report 1/2010 (G-YMMM); CRC and NTSB literature on water in jet fuel; Aeronautical Journal studies on SAF and fuel-line ice.

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What about hydrogen aircraft?

A 2035+ answer for part of the fleet



Time

Airbus hydrogen aircraft announced for an entry into service now in 2035+.
Safran is actively working on the development of key technological bricks (fuel system, fuel cell, dedicated turbines)

Volume & temperature

Liquid hydrogen is stored at −253 °C and needs about 4 times the volume of kerosene for the same energy.

Infrastructure

Low-carbon hydrogen production, liquefaction, cryogenic storage and refuelling at every airport served.

Sources: Airbus (Feb. 2025), EUROCONTROL. Hydrogen envelope indicative, based on published ZEROe concepts.

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The S in SAF: Sustainable… or Sovereign?

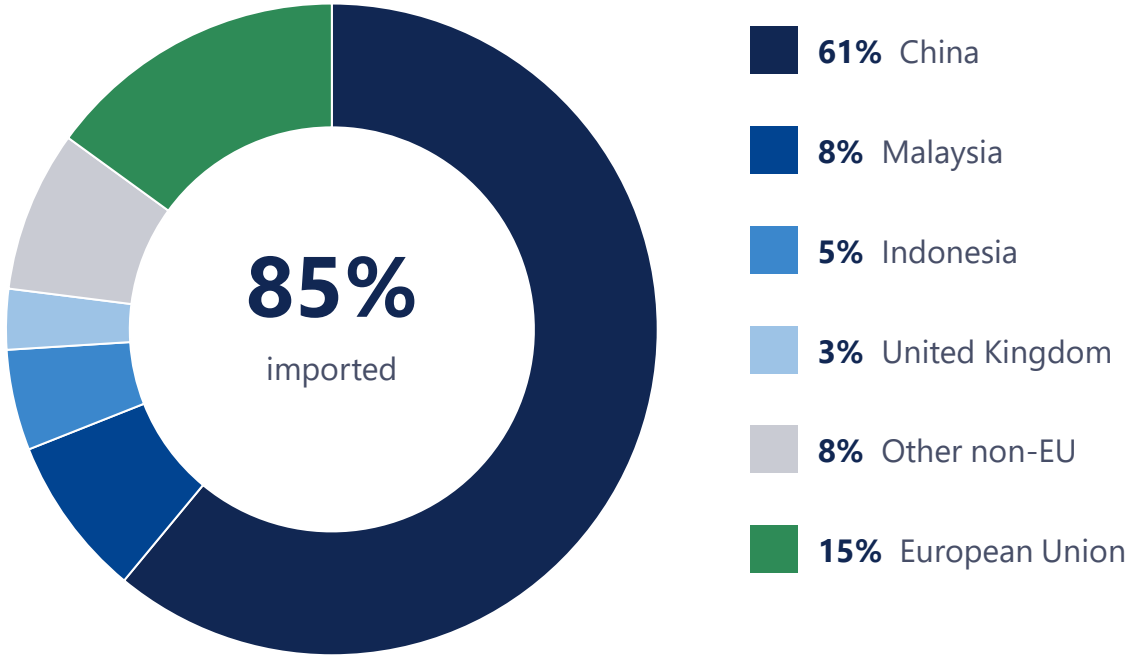
A transition that depends on other people's feedstocks
and other people's refineries is not necessarily a resilient one.

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Europe blends at home, but sources (mainly) abroad

Origin of feedstocks for SAF supplied in the EU, 2025



Used cooking oil = 80% of SAF supplied. 84% of SAF is refined in the EU, yet three quarters of its raw material comes from Asia.

Fossil jet fuel

~1/3 of Europe's jet fuel was imported in 2025, three quarters of it from the Middle East (IEA)

28 EU refineries closed or converted since 2009 (FuelsEurope)

Spring 2026 stress test

> $200 per barrel of jet fuel as Hormuz flows stopped; airlines cut capacity and the IEA warned of shortages

Two dependencies, one risk: no fuel, no flights.

Sources: EASA ReFuelEU Aviation Annual Technical Report 2026 (2025 data); IEA; FuelsEurope; market reporting, April 2026.

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“Amateurs talk strategy. Professionals talk logistics.”

Attributed to General Omar N. Bradley

Bio-feedstocks

residues, waste lipids, lignocellulose, from diversified and traceable sources

e-SAF

low-carbon hydrogen + captured CO_2

Fossil refining

still needed through the transition, and the host for co-processing

Hydrogen

liquid, for the first dedicated aircraft after 2040

One integrated European fuel system

Refineries and biorefineries

Co-processing units

Pipelines, depots, hydrants

Quality control at every step

Skills and industrial know-how

One goal
decarbonised flights
at today's level of safety

Keeping refining and fuel logistics in Europe is not nostalgia: the same sites, pipelines and people will carry tomorrow's molecules.

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Fuel quality at the right level: a job for all of us

Where should the quality bar sit for tomorrow's fuels?

Too tight	The right level	Too loose
Few pathways qualify, volumes stay small, costs soar: decarbonisation stalls.	Fit for purpose, backed by data, compatible with the entire fleet, today and tomorrow.	Safety margins erode, legacy aircraft become incompatible: unacceptable.

Who has to sit at the table

- **Engine & airframe manufacturers**
- **Energy producers & refiners**
- **Airlines & airports**
- **Regulators & standard bodies**
- **Military users**
- **Research labs**

Share data early, collaborate, test together, standardise once: OEMs / fuel producers and the critical rôle of coordination entities such as IAEG or others.

IAEG INTERNATIONAL AEROSPACE ENVIRONMENTAL GROUP

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Our flight plan to 2050

1

Burn less

RISE, lightweighting, better operations: every generation must bring its 20%.

2

Deploy SAF, now

The only lever acting on today's fleet. Every year of delay is paid in offsets.

3

Stay drop-in

Every drop compatible with every aircraft, from the oldest to RISE, military included.

4

Build it together, starting in Europe

Quality criteria set jointly with energy producers; production and logistics we control.

Less carbon. Never less safety.

One fleet, one fuel standard, one team: engine and airframe makers, energy producers, airlines and authorities.

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Annex – Armed forces: resilience first

Why military demand will not, on its own, drive SAF development

They ask for resilience

Right fuel **Any time** **Any place**

home territory and deployed operations

Not sovereignty, and in the short term not sustainability. Resilience comes from diverse resources, logistics and refining assets.

Constant budget: fuel vs. ammunition

€7,520/t

e-SAF vs. €640/t for fossil jet, 2025 (EASA)

Swapping 10% of NATO Europe's military jet fuel for e-SAF: **≈ €1.7 bn more a year***, taken from vehicles or munitions. No one in uniform will sign that.

Not the game changer for SAF volumes

~1%

of NATO Europe liquid fuels burnt by its forces in peacetime (3.7 Mt/yr)

up to 60%

of civil jet fuel redirected to the military in an Article 5 war by 2035 (45% at once)

Compatibility still to be demonstrated

F-34

NATO single fuel

Legacy engines, helicopters, ground vehicles, specific additives, long-term war stocks: **not every civil-qualified SAF is cleared for military use.** Large qualification work lies ahead.

+ currently NO SAF quality of F-44 jet fuel (aeronaval forces)

Resilience = diversified resources + global logistics + refining assets + fully compatible fuels.

** Illustrative: 3.7 Mt × ~66% jet share × 10% × €6,880/t price gap. Sources: NATO ENSEC COE, Fuelling the Forces to 2050 (Sept. 2026); EASA 2025 reference prices; EUISS.*

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