AVIATION CO_2 REDUCTIONS

ONLINE STOCKTAKING PREVIEW

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Reducing aviation CO_2 emissions – Challenges and solutions

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Reducing aviation CO_2 emissions – Challenges and solutions

01 The energy transition in aviation: among the hardest to abate sectors

An overview of the key attributes of commercial passenger aviation that make the energy transition particularly challenging

02 Operational and technical energy efficiency opportunities

“Right-sizing”; Air Traffic Management and other operational fuel burn reduction measures; engine and aircraft design potential in next-gen and future generation aircraft

03 Alternative aviation fuels: SAF potential and costs

Current market landscape and future outlook
Hurdles to scaling up Sustainable Aviation Fuels
Key policy considerations

I. The energy transition and aviation

A number of factors make commercial passenger aviation climate impacts particularly hard to abate

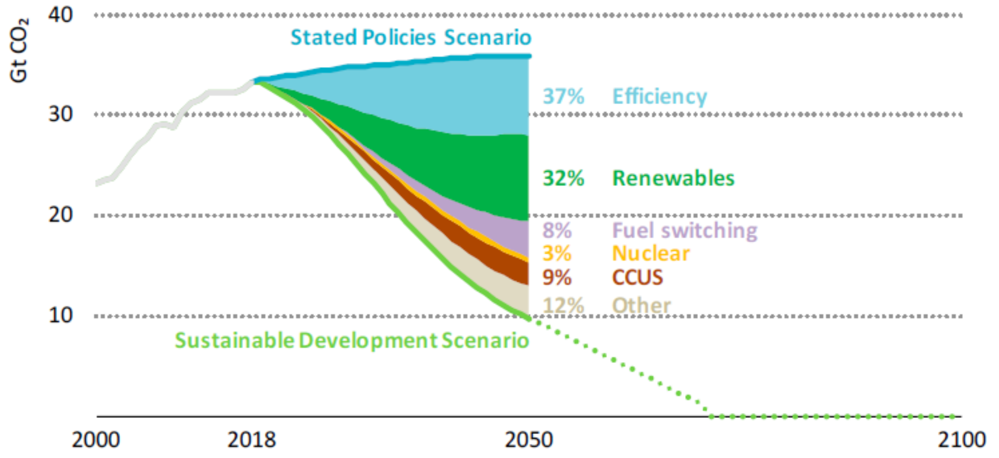
- **Demand**: Robust activity growth driven by rising incomes
- **Structure**: slim profit margins, high capital intensity, long-lived assets
- **Physics**: requires high energy density fuels, non-CO_2 climate forcing effects are complex and significant

IEA Scenarios and transport trajectories

The **Sustainable Development Scenario** (SDS):
(1) decarbonise rapidly,
(2) sharply reduce air pollutant emissions, and
(3) ensure universal energy access by 2030.

The **Stated Policies Scenario** (STEPS):
incorporates existing commitments,
including the Nationally Determined Contributions.
Not consistent with climate objectives,
but is still a significant shift from "business as usual."

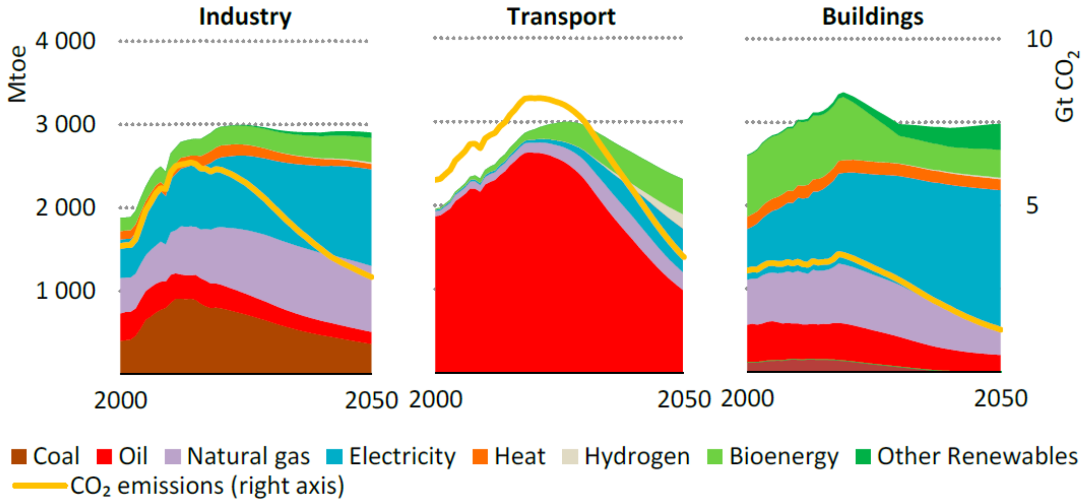
Figure 2.1 ▷ Energy-related CO_2 emissions and reductions by source in the Sustainable Development Scenario



Efficiency and renewables provide most emissions reductions, but more technologies are needed as emissions become increasingly concentrated in hard-to-abate sectors

Note: CCUS = carbon capture, utilisation and storage.

Figure 2.6 ▷ Total final consumption by sector and fuel in the Sustainable Development Scenario



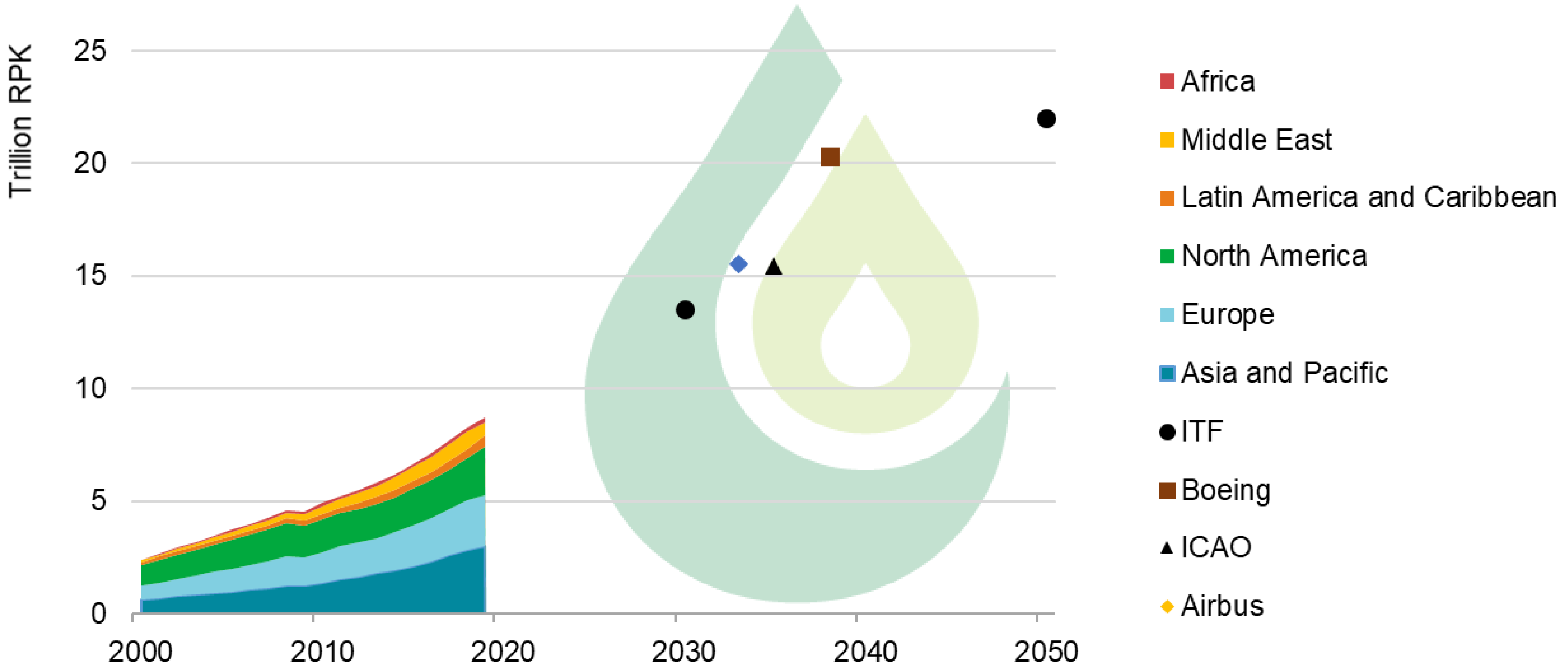
A shift to low emitting energy sources cuts end-use emissions by 57%, but the drop in total final consumption in buildings flattens out due to expanding electricity access

Source: World Energy Outlook, 2019

Different energy supply and demand sectors, as well as different transport modes decarbonise at different rates, and have distinct levers for reducing emissions

Strong activity growth – both historical and projected

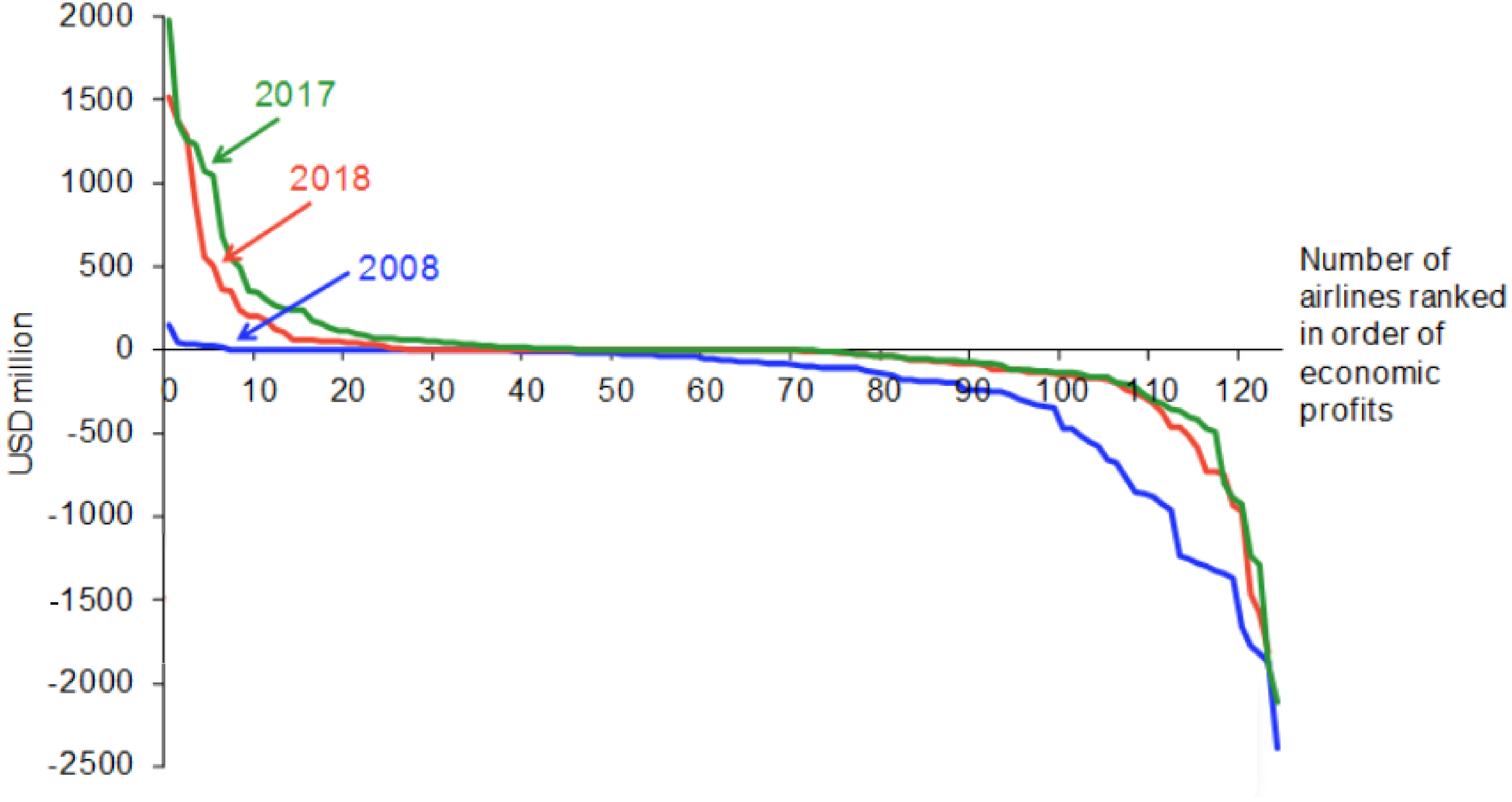
Commercial passenger aviation: historical and projections



IEA modelling suggests that strong policies and technology deployment are needed to promote efficiency and fuel switching, and to moderate demand growth

Airlines operate in a very competitive market

World's airlines ranked by economic profits

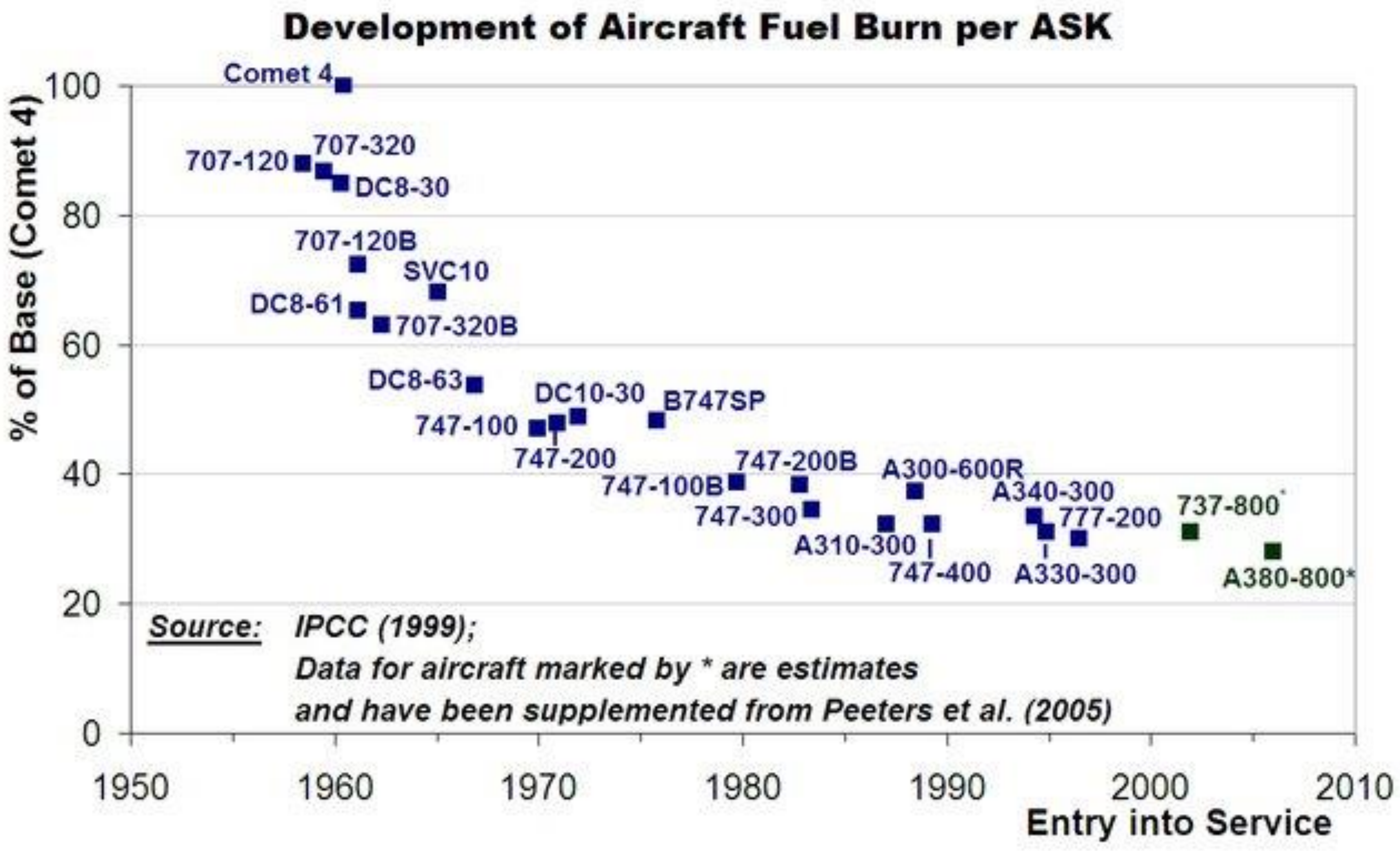


Source: IATA Economics using data from a McKinsey study for IATA

Design improvements to aircraft are mostly evolutionary

High capital intensity implies significant risk to making fundamental changes to aircraft design

Historical fuel efficiency improvements in aircraft families



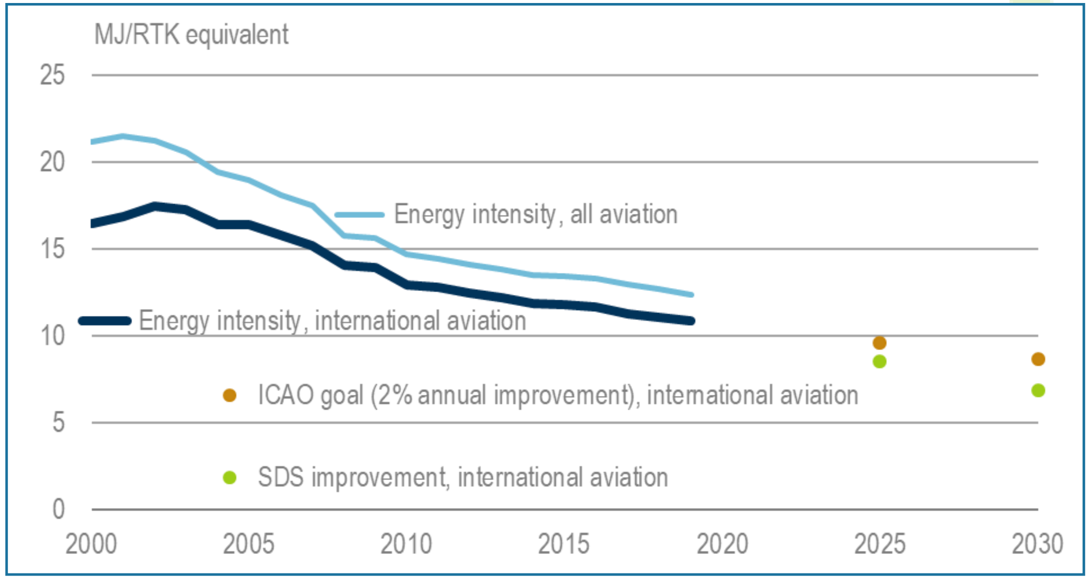
Source: Martin Schaefer, Forecast of Air Traffic's CO_2 and NOx Emissions until 2030, 7th Air Transport Research Society (ATRS) World Conference, Bergamo

Design improvements to aircraft are mostly evolutionary

High capital intensity implies significant risk to making fundamental changes to aircraft design

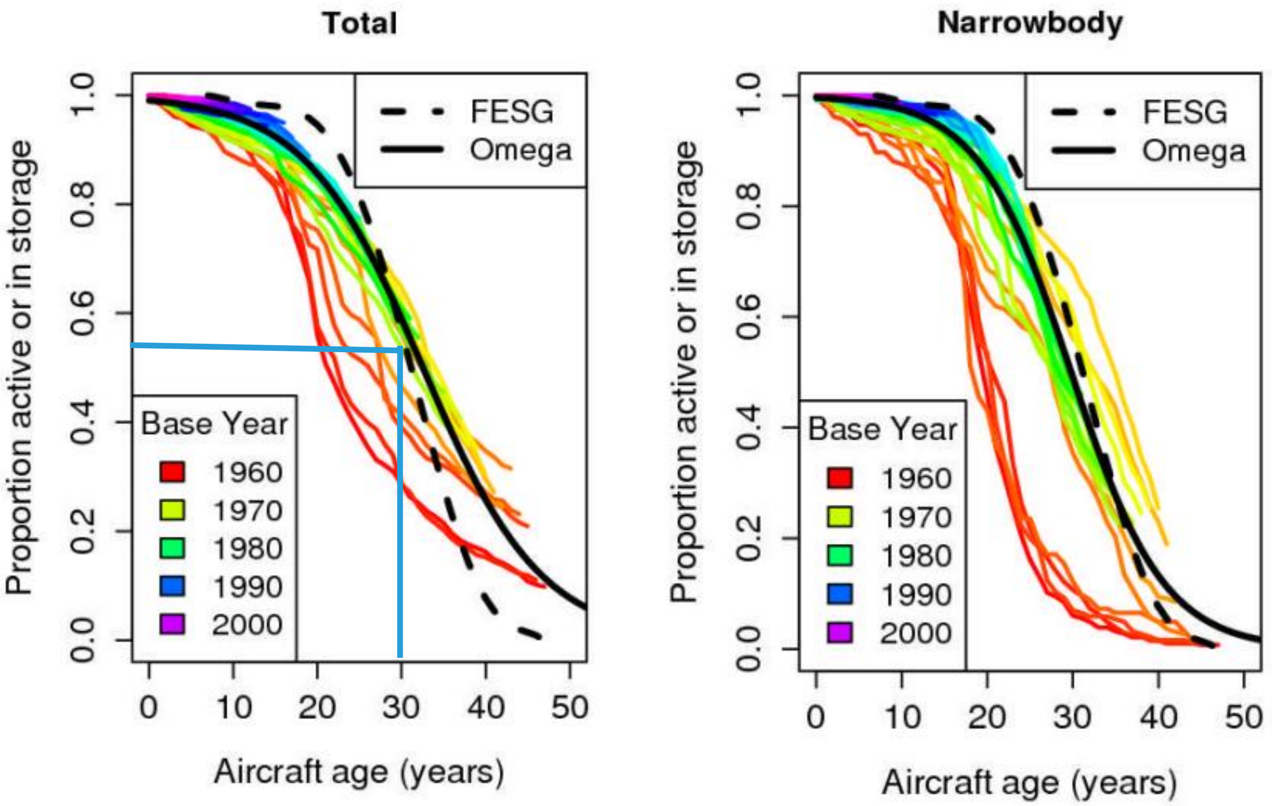
Average annual rates of change

	Emissions CO_2	Energy intensity EI (MJ/RTK)	Activity RTK
1980-2015	2.2%	-3.2%	5.4%
2000-2015	1.7%	-3.0%	4.8%



Source: Tracking Clean Energy Progress, IEA, www.iea.org/reports/tracking-transport-2020/aviation

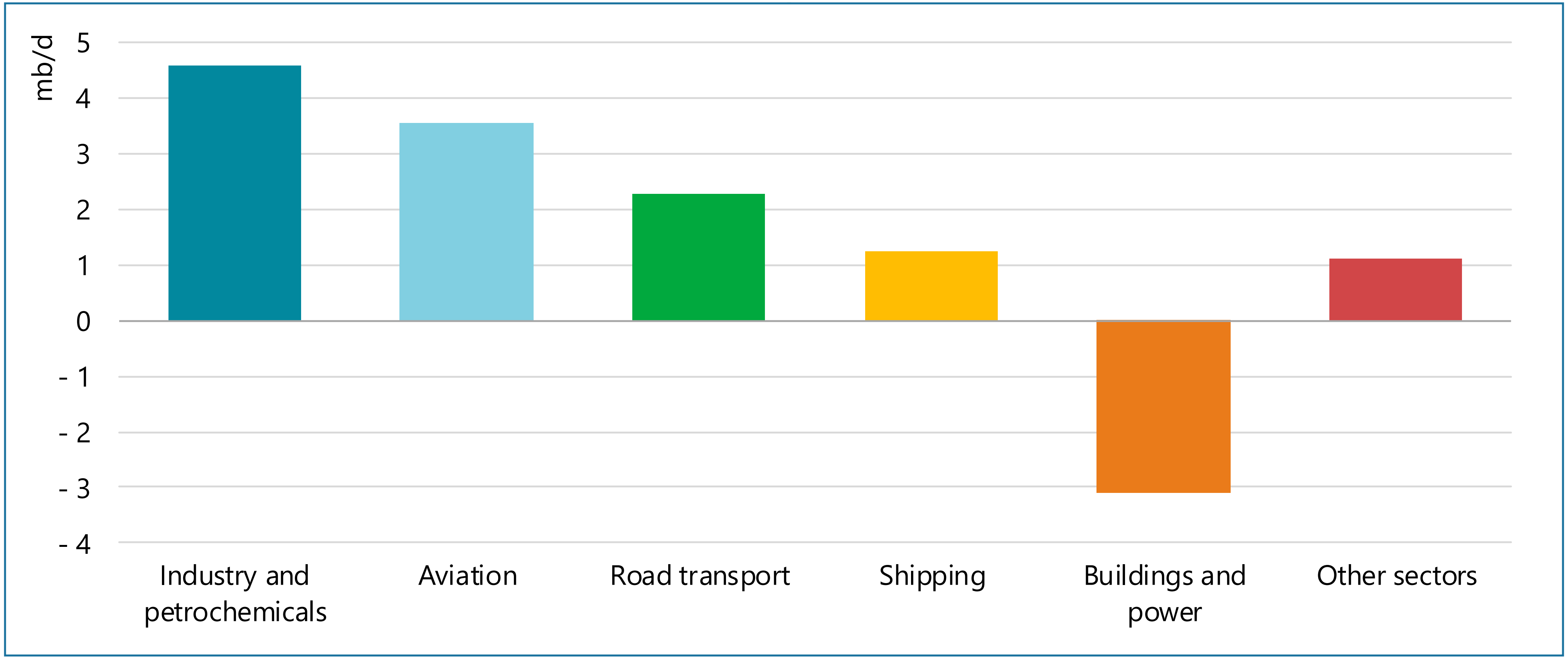
Aircraft are long-lived assets



Source: Morrel and Dray, 2009, "Environmental aspects of fleet turnover, retirement and life cycle" Final Report, Omega

Aviation could become the 2nd largest driver of oil demand growth

Oil demand growth by end use 2018-40 in the IEA's Stated Policies Scenario



Source: IEA, World Energy Outlook 2019

Doubling of passenger activity sees oil demand from aviation increase 50% by 2040.

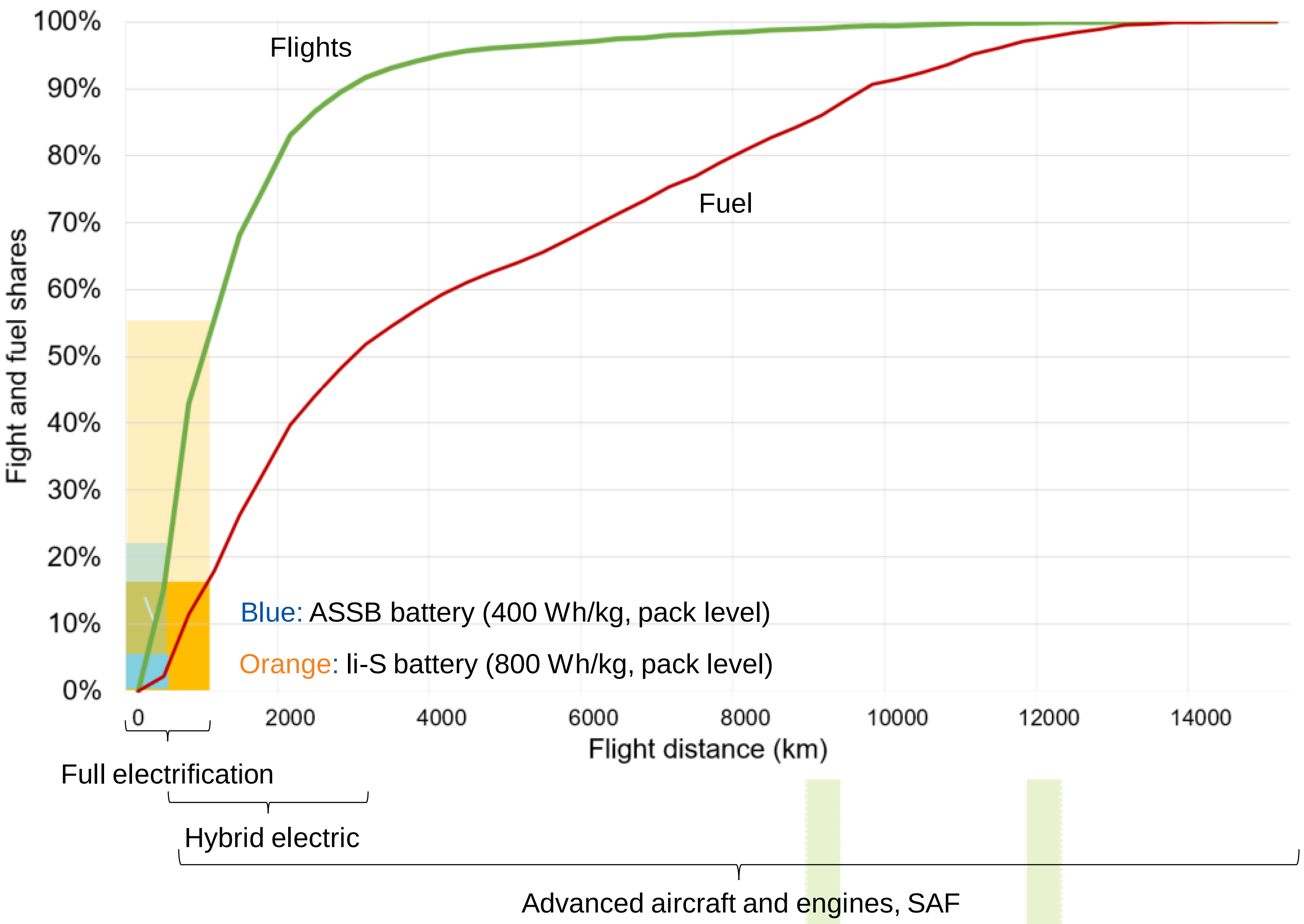
II. Opportunities for energy efficiency

A number of near-, medium- and long-term energy efficiency options can continue to reduce fuel burn

- No single technology solution
- Different solutions for different distance flights
- Both efficiency and low-carbon fuels are needed

Long-term efficiency and fuel opportunities depend on distance

Technology potential for CO_2 emissions reduction declines as distances increase



Example efficiency opportunities in operations and technology

Current generation

- Single engine or electric taxiing
- Cabin weight reduction
- Congestion management
- Optimised departures / approaches
- Reduced cruise inefficiency
- Increased engine / aero maintenance
- Increased use of composites

Next gen

- Ultra-high bypass ratio
- Double-bubble
- Open rotor

Disruptive (likely 2040 at earliest)

- Hybrid-electric aircraft (Boundary layer ingestion)
- Blended wing-body aircraft
- Full electric aircraft
- Hydrogen jet engine aircraft
- H2 fuel cell aircraft

Efficiency improvements (MJ/RTK)

Average annual rates of change

	Emissions CO_2	Energy intensity EI (MJ/RTK)	Activity RTK
1980-2015	2.2%	-3.2%	5.4%
2000-2015	1.7%	-3.0%	4.8%
2005-2015	1.2%	-3.4%	5.3%
2015-2050	2.4%	-1.6%	4.0%

In the IEA SDS, all technologies that are at TRL level 6 (large demonstration of the complete technology at scale) and above are deployed. Strong policies (e.g. taxation, carbon pricing, and SAF adoption) are needed to drive this aggressive deployment.

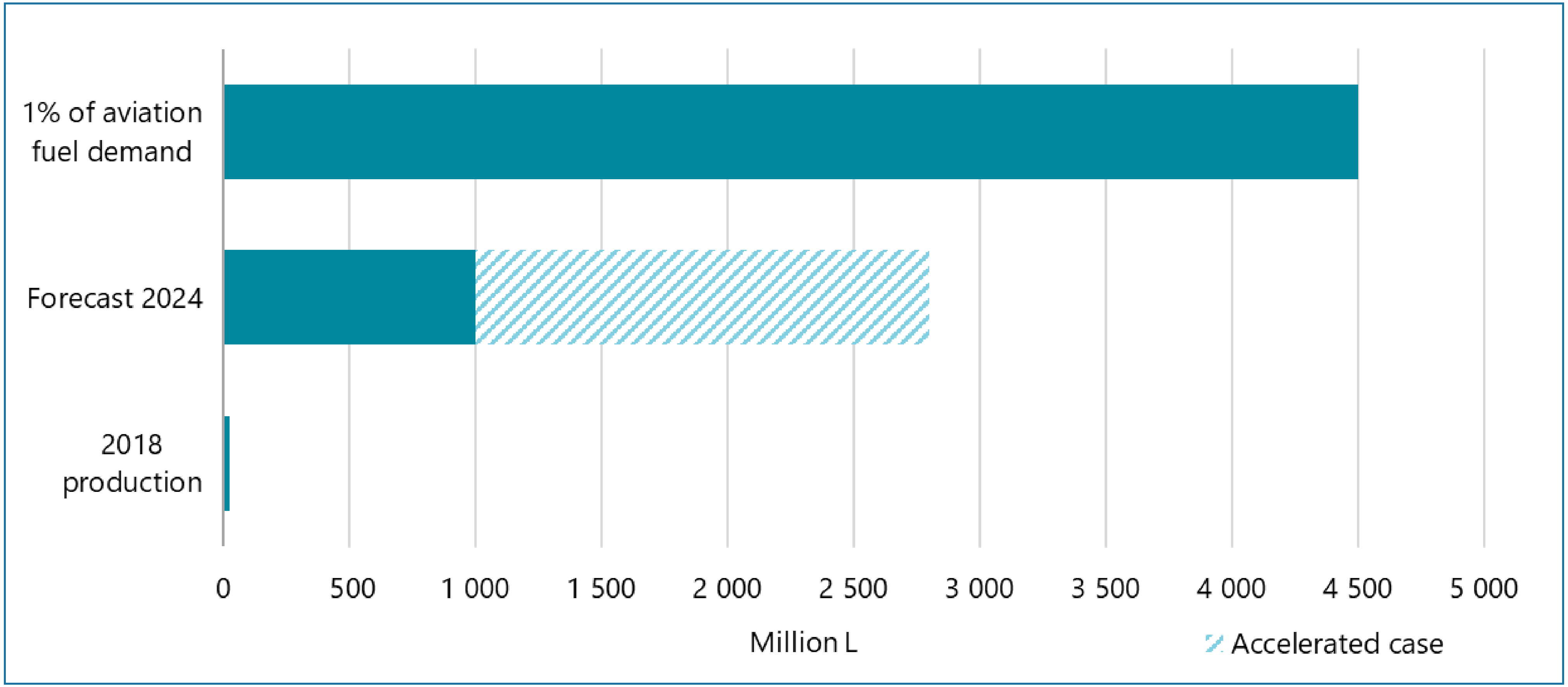
III. Sustainable aviation fuels: SAF potential and costs

Low carbon liquid fuels are a key solution for decarbonising aviation in the long run

- The biofuels in the SDS
- Near term prospects for SAF production
- Key hurdles to scaling up Sustainable Aviation Fuels

Aviation biofuels are on the runway, but have not yet taken off

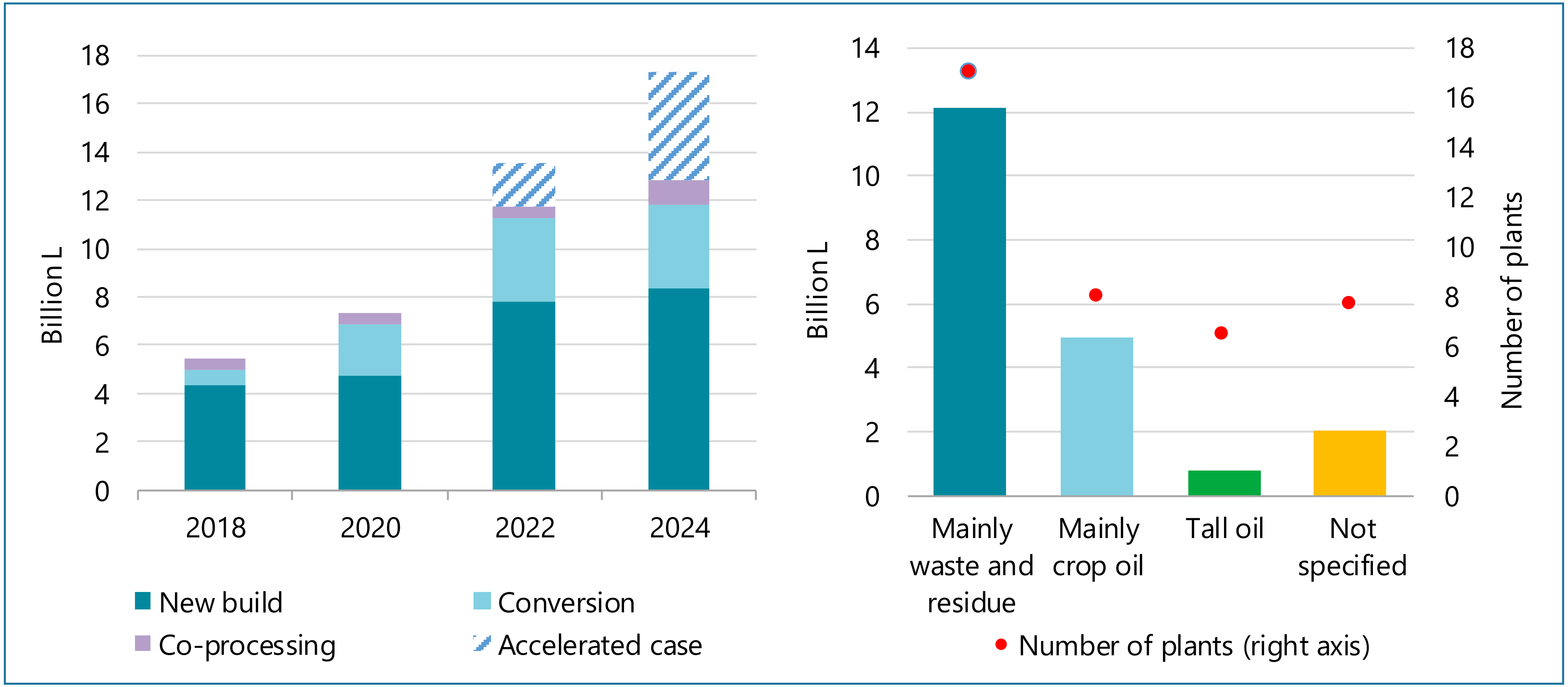
Aviation biofuel production forecast



Between 1-3 billion L of aviation biofuel production anticipated by 2024, as several HVO plants plan to produce HEFA jet fuel. But higher market penetration is needed to make consumption self-sustaining.

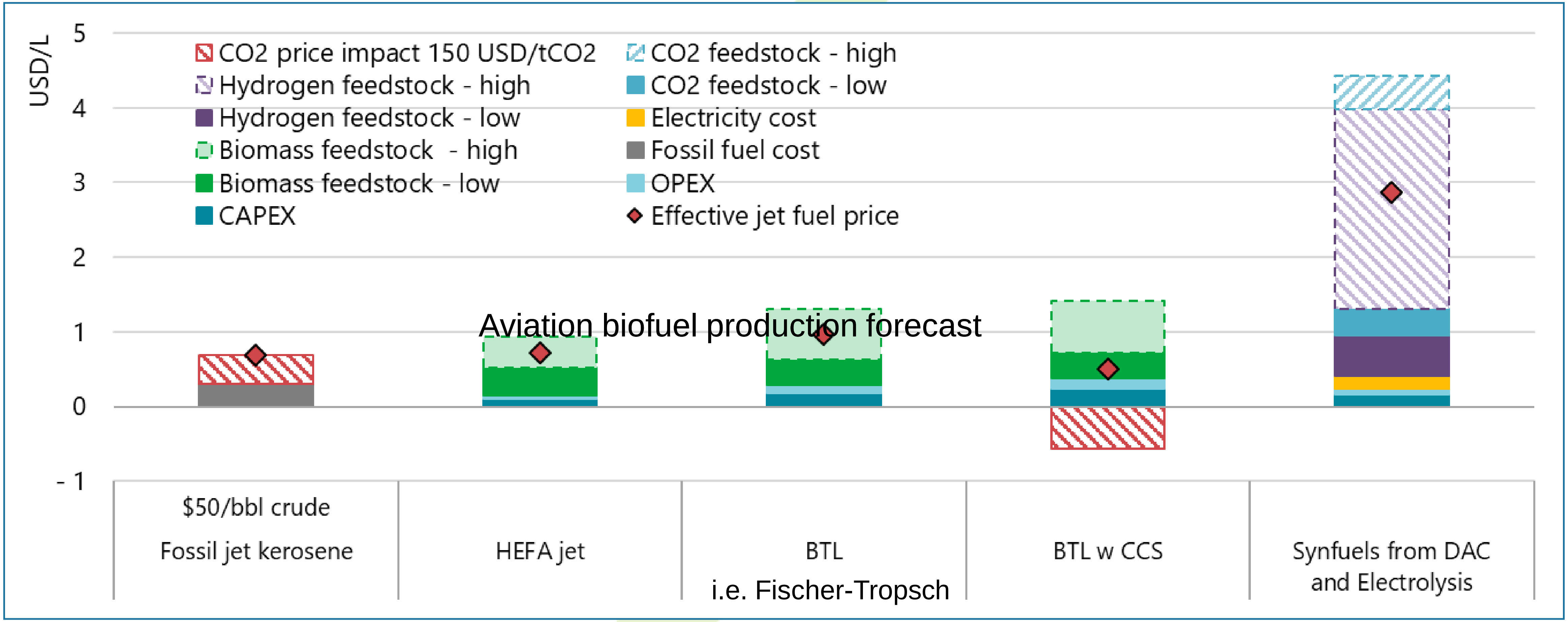
Expansion of HVO output will also boost HEFA production capacity

HVO production forecast (left) breakdown of plant capacity by feedstock type (right)



Mobilisation of supply chains for low carbon waste fats, oils and grease feedstocks will be crucial to ramping up HVO and HEFA production.

A key barrier to SAF uptake is their higher cost than fossil jet fuel

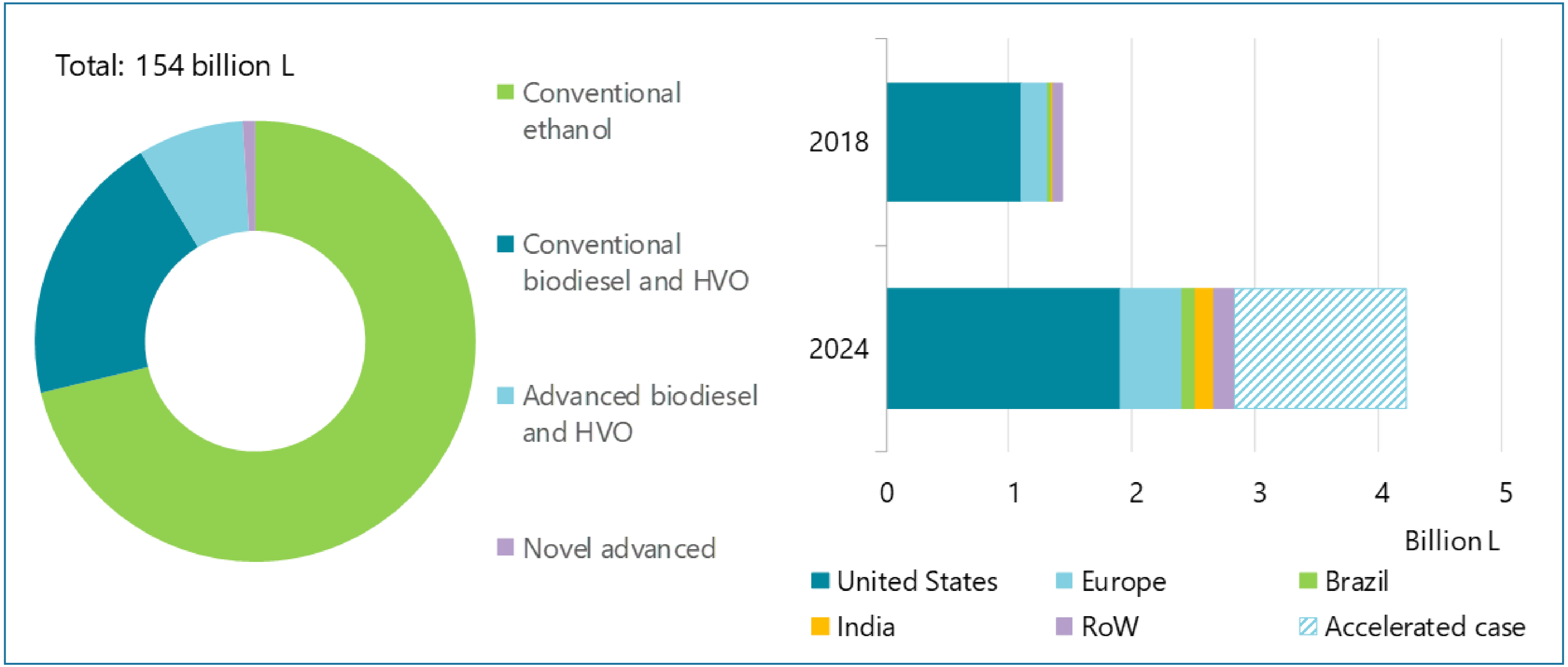


Source: IEA analysis (preliminary and unpublished, do not cite or distribute)

Greater HEFA production capacity and development of less mature technologies that can use residue and waste feedstocks are needed to increase SAF production and reduce costs, in addition to strong policy measures.

A stronger push of biofuel technology innovation is needed

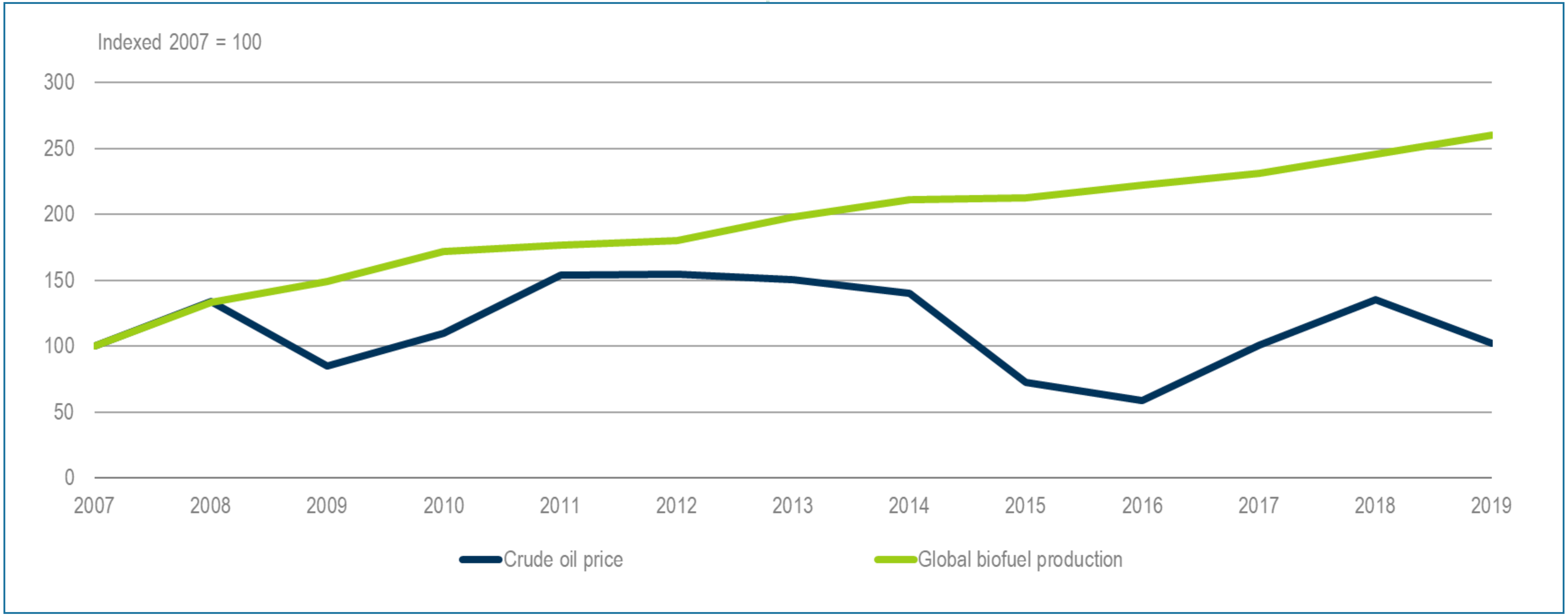
Biofuel production overview, 2018 (left), novel advanced biofuel production by country / region (right)



USA leads new biofuel technology development, but by 2024 these fuels only provide <2% of biofuel production as the high investment risk of moving from demo- to commercial-scale hampers growth.

Policies are effective in delivering sustained biofuel output growth

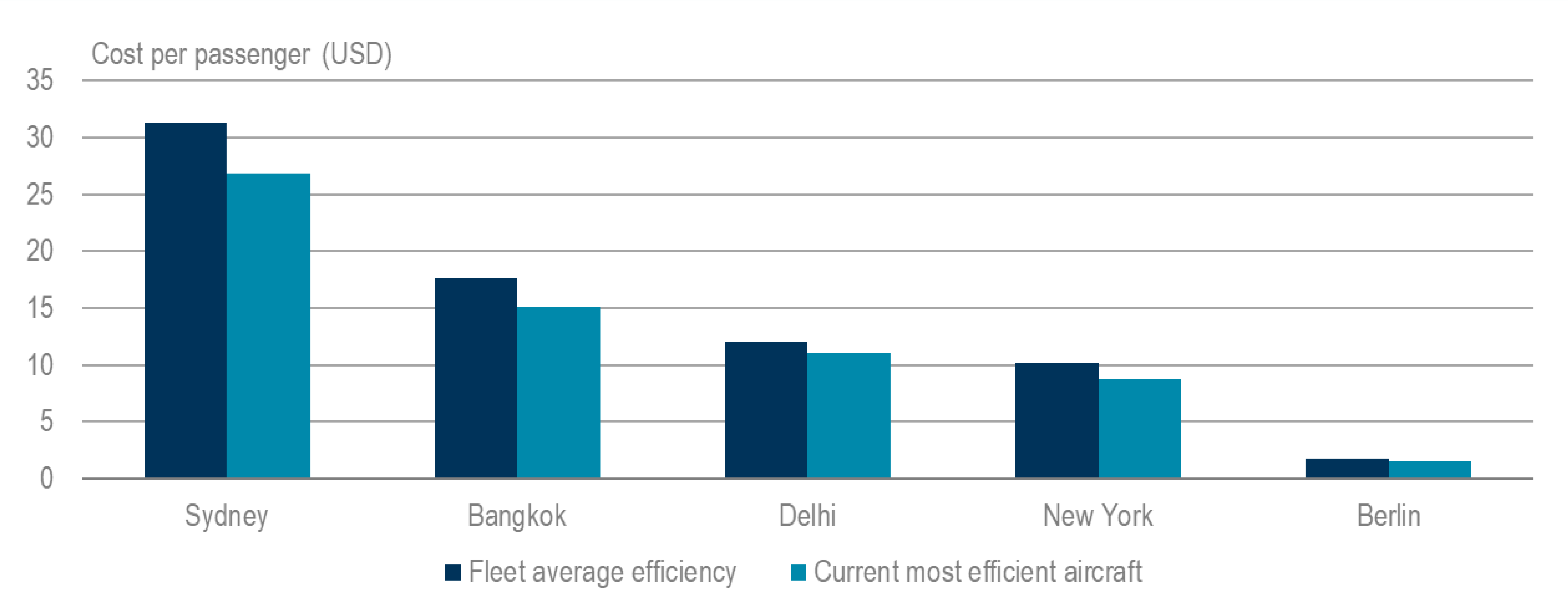
Crude oil price and biofuels production 2007-19



As most demand is policy driven, low oil prices have not stopped biofuel production increasing. Policy support for aviation biofuels is gaining momentum (CA LCFS, UK RTFO, Norway, EU RED).

Or is it feasible to pass extra SAF costs to passengers?

Cost premium of commercial aviation biofuels (15% blend) per passenger from London



The additional cost per passenger from biofuel blending may not be prohibitive compared to other elements that influence ticket prices, such as seating class, time of purchase or taxation.

For further insights and analysis….

From the IEA:

The Energy Technology Perspectives 2020 (forthcoming later this year)

Renewables 2019 market report Aviation biofuels commentary (2019)

Tracking clean energy progress: biofuels and aviation (currently being drafted for 2020)

The Future of Hydrogen

World Energy Outlook (WEO) 2019

The Global Electric Vehicles Outlook, 2019 and 2020 (forthcoming)

Renewables 2018 market report (with SAF analysis), now available free of charge

Technology Roadmap - delivering sustainable bioenergy, 2017

How2Guide for Bioenergy, 2017

From other researchers in aviation, energy, and sustainability:

The Air Transportation Systems Lab: www.atslab.org

University College London: the Aviation Integrated Model (AIM)

The International Council on Clean Transportation (ICCT): Aviation homepage

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