The Road to Sustainable Aviation Fuels - More Questions than Answers?

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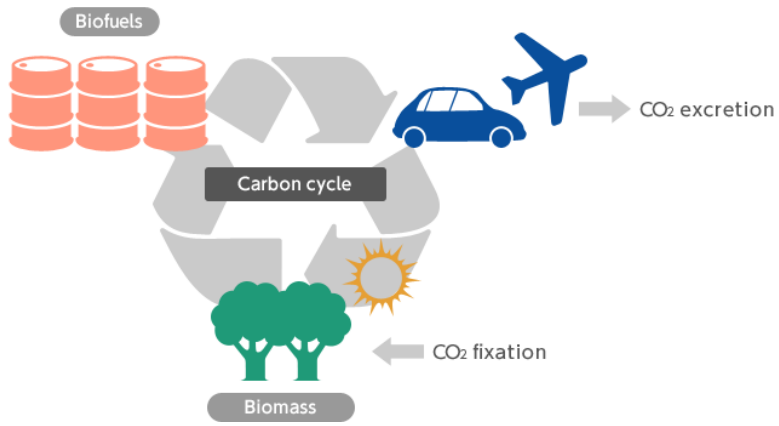
Sustainable aviation fuels – a brief overview

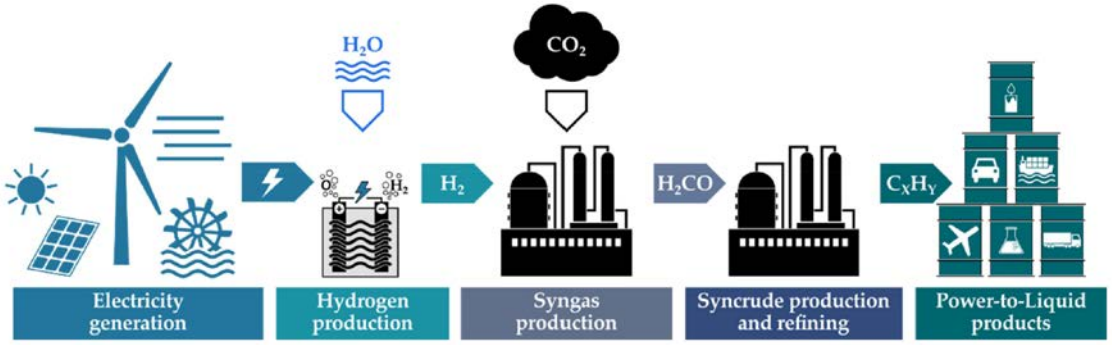
- Jet Fuel: Mixture of cyclic and acyclic hydrocarbons with 8-16 carbon atoms
- Basic notion of SAF: closed loop of carbon / green electricity
- Feedstock: Biomass, waste
- “Feedstock” used for e-fuels: water (hydrogen) and CO_2 (carbon)
- Challenges in e-fuel production:
  - Availability of electricity from renewable sources
  - Efficiency of hydrogen production
  - Carbon sources (direct air capture vs. biogenic sources vs. industrial sources)

⇨ The technological roadmap is plausible, but how about the economics of it all?

The concept of carbon neutrality



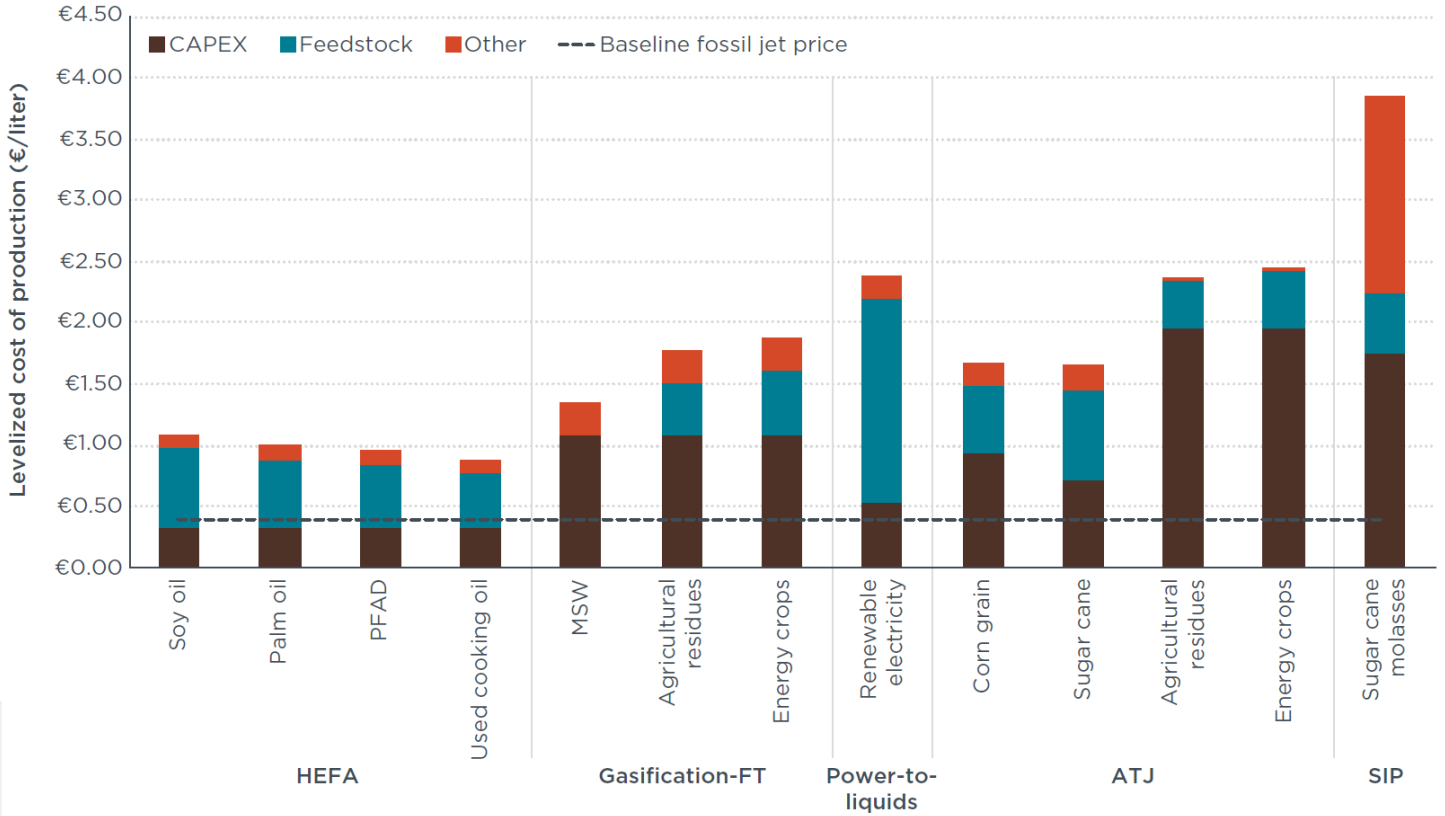
Source: https://www.rite.or.jp/bio/en/biofuels/



Source: Meurer/Kern (2021)

How to finance market uptake of SAF?

- SAF will be two- to six-fold more expensive
- “Biofuels” are likely to be cheaper than e-fuels, but feedstock limited (at least in Europe)
- Carbon pricing / taxation alone is likely not able to achieve market uptake in high quantities



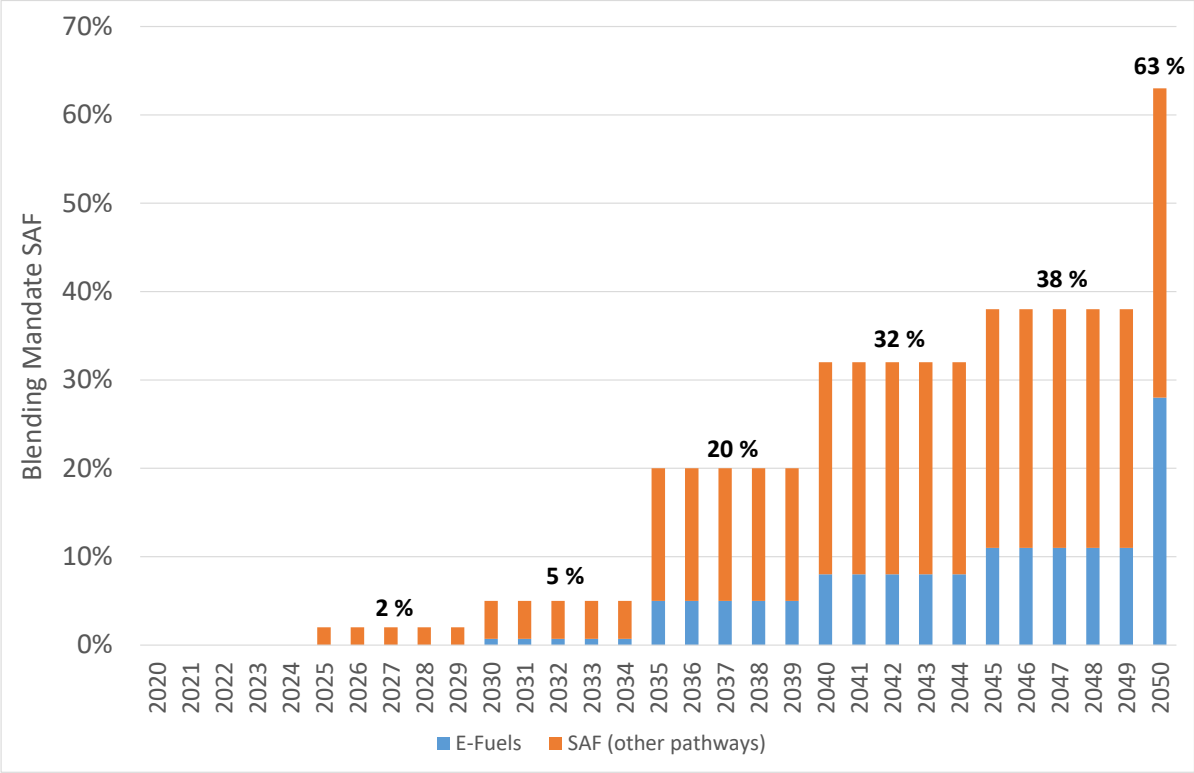
Source: ICCT

⇨ Regulatory intervention necessary to bring SAF into the market

The current political situation in Europe

- European Commission initiative ReFuelEU Aviation as part of the Fit-for-55 package proposes blending mandate in combination with a ban on tankering
- Several EU Member States have introduced SAF quotas already before EU proposal
- No solution to bridge the gap between fossil fuel /SAF cost differential – users (passengers & shippers of air cargo) shall pay
- Huge scale-up of production facilities necessary

Fit for 55 – proposed E-Fuels/SAF blending mandate



Sustainable aviation fuels from an economist's perspective

View of some economists*:

- Sustainable aviation fuels are well too costly for society, compared to other carbon abatement technologies
- Blending mandates are not a desirable policy
- Carbon pricing is a sufficient instrument for the internalization of external effects

*) Cf. Stef Prost (KU Leuven) – Hong Kong Polytechnic University / GARS webinar "Climate Change and Aviation: 3 Questions", 20th April 2022

But:

- Regulating carbon emissions from aviation **effectively** on a global scale is an illusion
- Pressure from politics and society for abatement of carbon in the aviation industry
- SAF is probably the only realistic technology to reduce carbon emissions in aviation
- Cost discussion leaves out long-term economies of scale / learning curve effects

Economic incentives for SAF market uptake

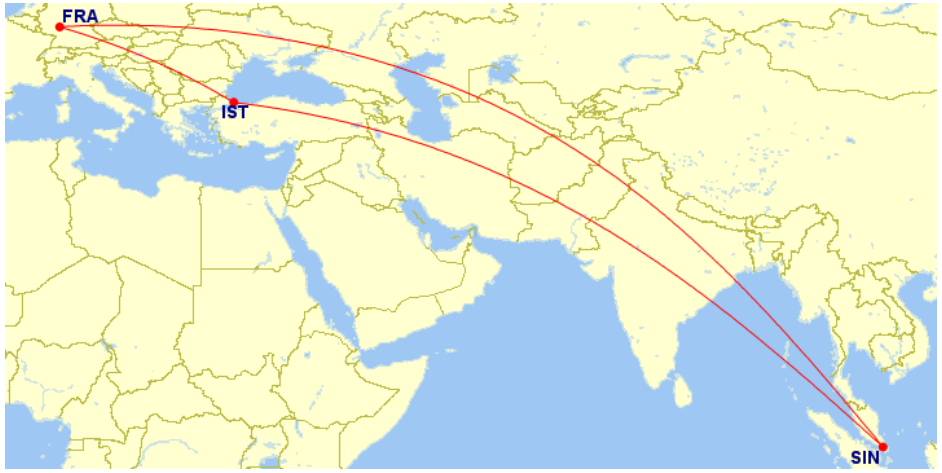
- Aviation lobby groups propose aviation-related revenues (e.g. APD, ETS auction revenues) to be earmarked for SAF market uptake
- Germany started tendering process, paying a price differential between SAF production costs and market prices to achieve scale economies / learning curve effects quickly
- USA introduced tax credits for SAF producers / blenders

- Multiple options from the textbooks:
  - Tradable credits (book & claim)
  - Surcharge / compensation payments

Which economic incentives (if any at all are required…) are efficient to support SAF market uptake?

What about competitive distortions from blending mandates?

- ReFuelEU Aviation proposal suggests equal treatment for all flights departing airports in the EU – including an intended ban on tankering to minimize competitive distortions
- Still, network airlines worry about competitive distortions on long-haul flights/itineraries
- E.g. on a flight from Frankfurt to Singapore via Istanbul, less than 20 % of the total flight distance would be subject to the blending mandate compared to a direct flight
- In addition, intra-EEA holiday traffic (and destinations) could be affected by traffic flows shifted to non-EEA places (where only the EEA outbound segment is subject to ReFuelEU but not the return segment)



Source: gcmap.com

How big is the risk of passengers choosing another itinerary because of price differentials?

Why do European airlines complain?

- ReFuelEU Aviation proposal targets a quota of 63 % SAF in 2050
- IATA's commitment is 65 % SAF in 2050
- All major network carriers globally are part of IATA

- USA: "Grand challenge" – 3 billion gallons (9 million tons) SAF by 2030, 35 billion gallons (106 million tons) SAF by 2050

- SAF initiatives around the world, e.g. Neste 1 million-ton-plant in Singapore…

Does ReFuelEU Aviation really create a competitive disadvantage?
Are IATA's voluntary commitments credible?

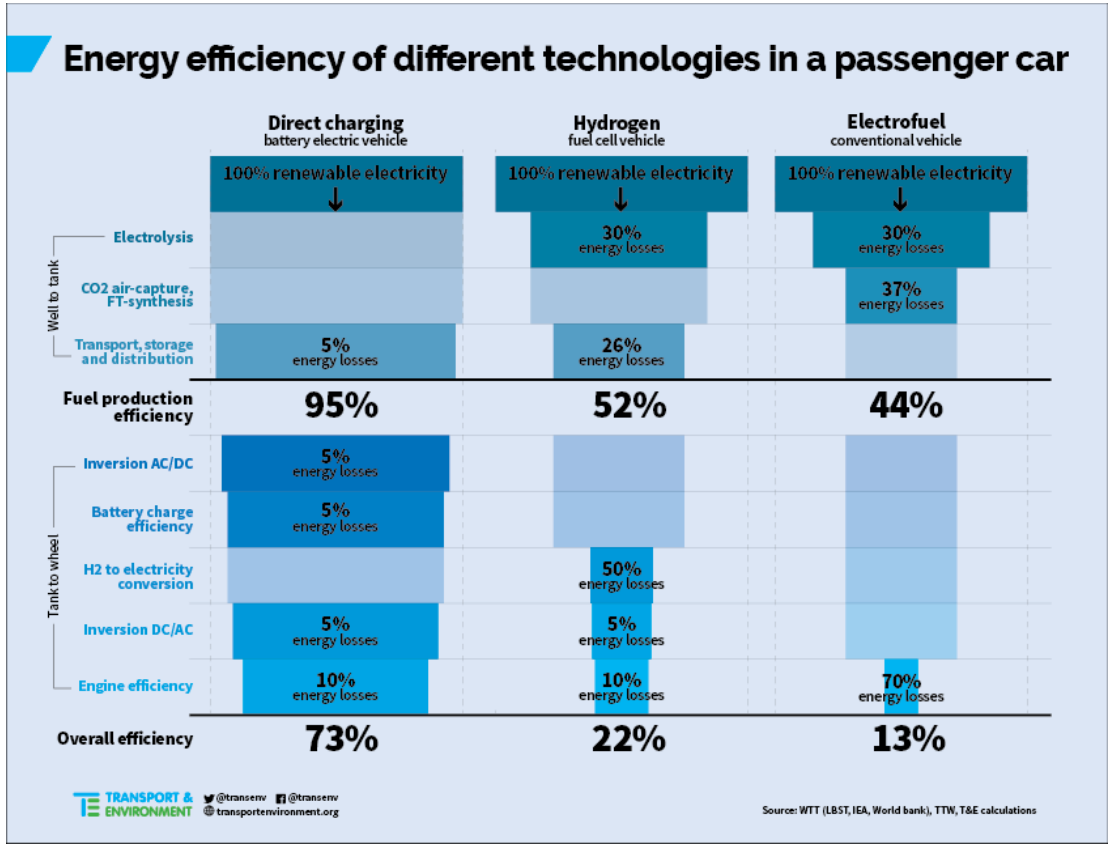
Source: Lufthansa

Is hydrogen the better alternative?

- Triple gravimetric energy content (120 MJ/kg vs. 43 MJ/kg) compared to Jet A1, extremely low density (71 kg/m^3 vs. 800 kg/m^3) ⇨ liquid hydrogen of the same energy content has six times the volume of kerosene
- Liquid hydrogen has a temperature of below -252°C ⇨ extreme challenge concerning storage and handling
- Intermediate product for sustainable aviation fuels
- Challenges in aircraft development and airport infrastructure

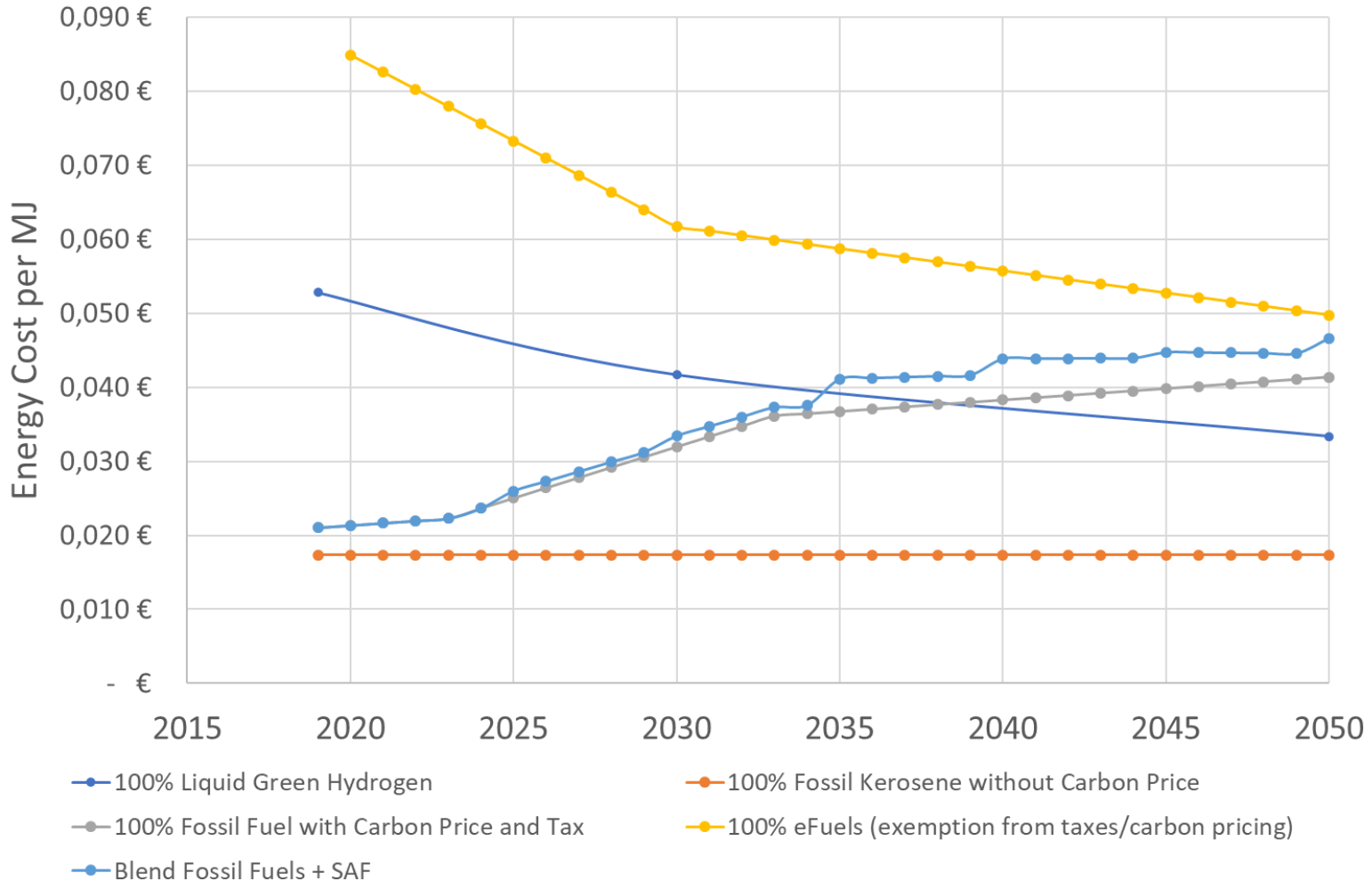
Taking into account all costs – which pathway is the most efficient for aviation?

- Switch to SAF
- Switch to hydrogen
- Continue use of fossil fuel + carbon price

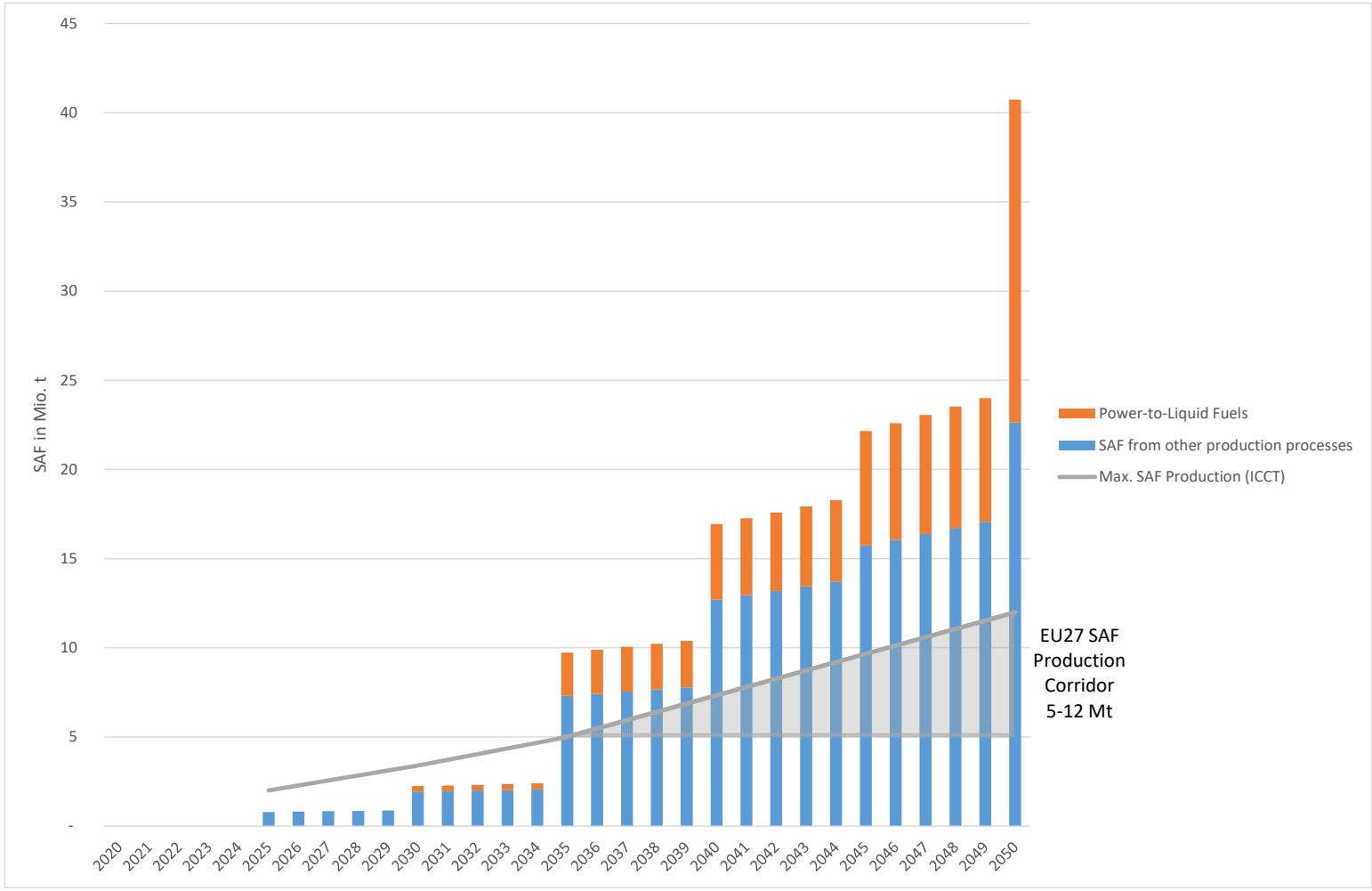


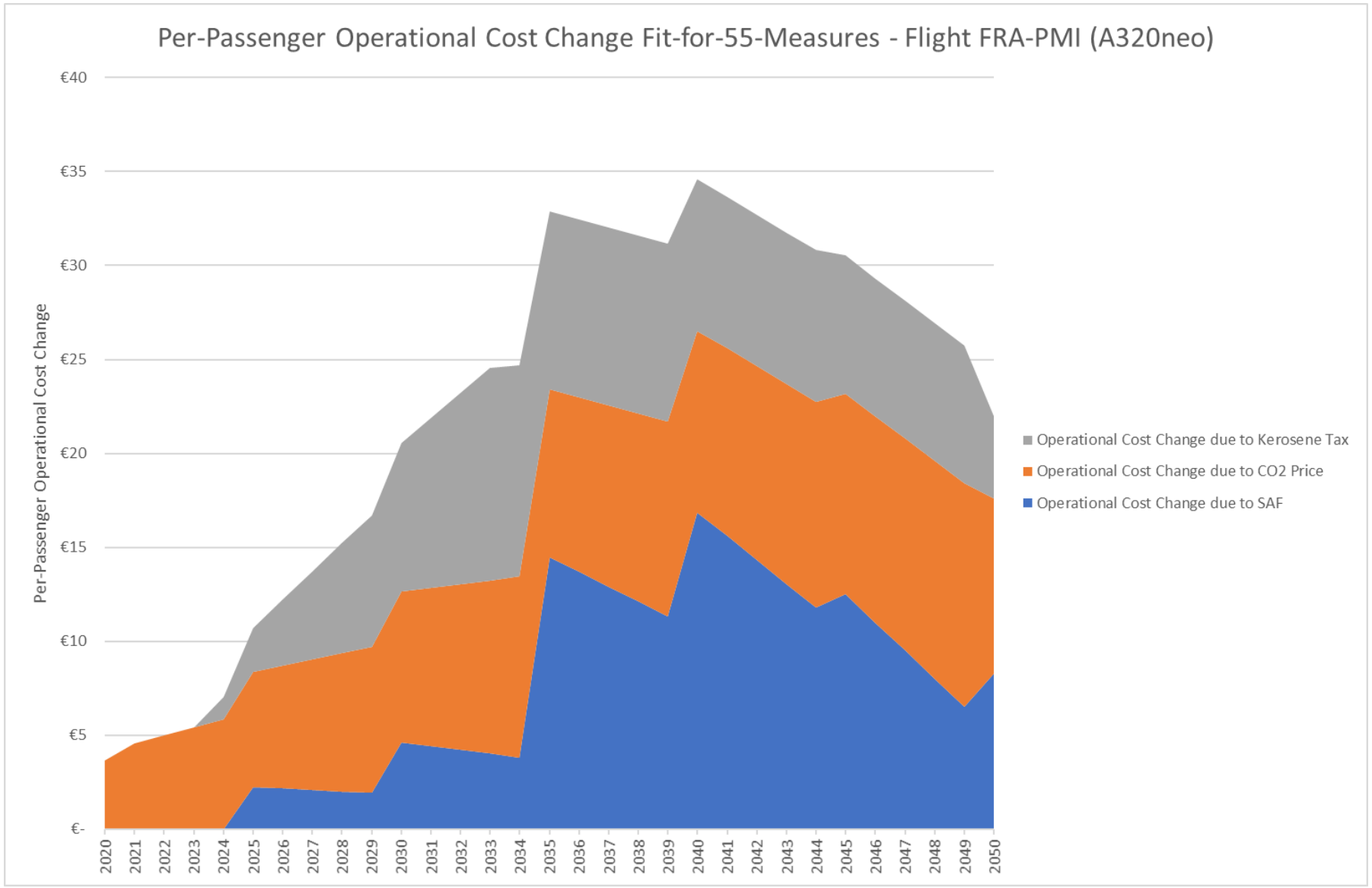
Annex

Expectations of price development for energy carriers in aviation up to 2050



SAF demand in EU27 and limitations of biomass up to 2050




Per-Passenger Operational Cost Change Fit-for-55-Measures - Flight FRA-PMI (A320neo)
Per-Passenger Operational Cost Change
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Operational Cost Change due to Kerosene Tax
Operational Cost Change due to CO2 Price
Operational Cost Change due to SAF