Role of Low Carbon Fuels for Aviation, Maritime, and Land Transport

Moderator:

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Senior Vice President, Research & Technology Development
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Executive Director, Commercial Aviation Alternative Fuels Initiative (CAAFI)

Panelists:

Rik Brouwer
GHG and Market Analyst
SkyNRG

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Senior Future Fuels Manager, Maersk Decarbonisation, Future Fuels
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Sustainable Aviation Fuel Observations

Steve Csonka
Executive Director, CAAFI

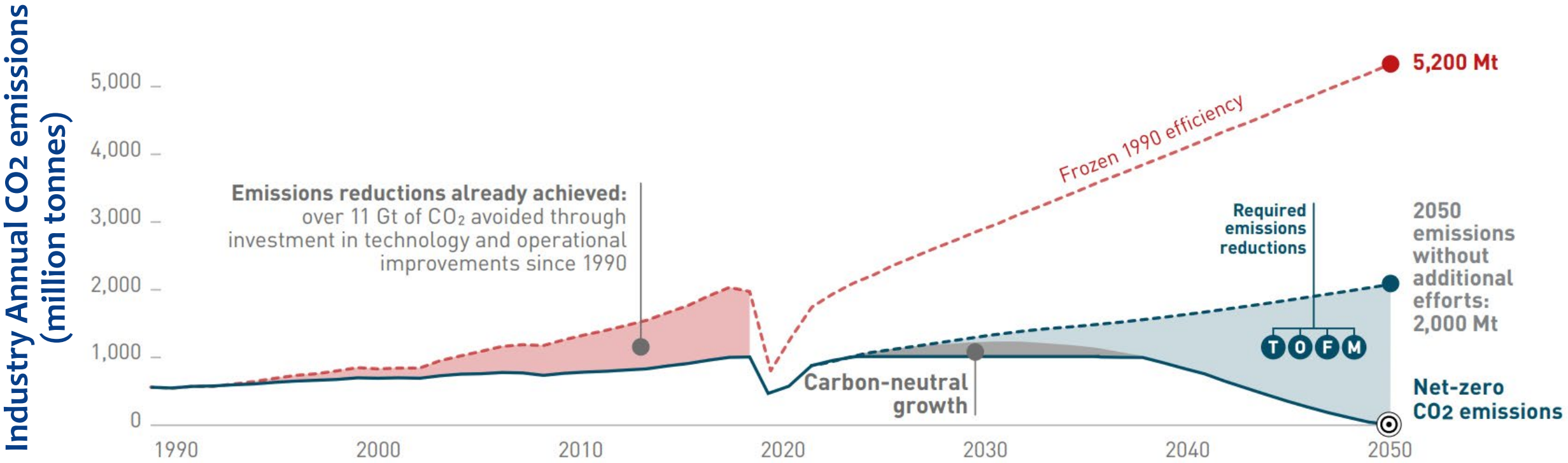
First flight from continuous commercial production of SAF
UAL 0708, 10 March 2016, LAX-SFO

Fuel from World Energy - Paramount (HEFA-SPK 30/70 Blend).

Only U.S. facility offering continuous production of SAF at present.
Other batch production & tolling occurring due to extreme customer interest.

19Apr'22

Civil Aviation commitments on CO_2 reductions



T Technology, including radical new
O Operations and Infrastructure
F Sustainable Aviation Fuels
M Market-based measures

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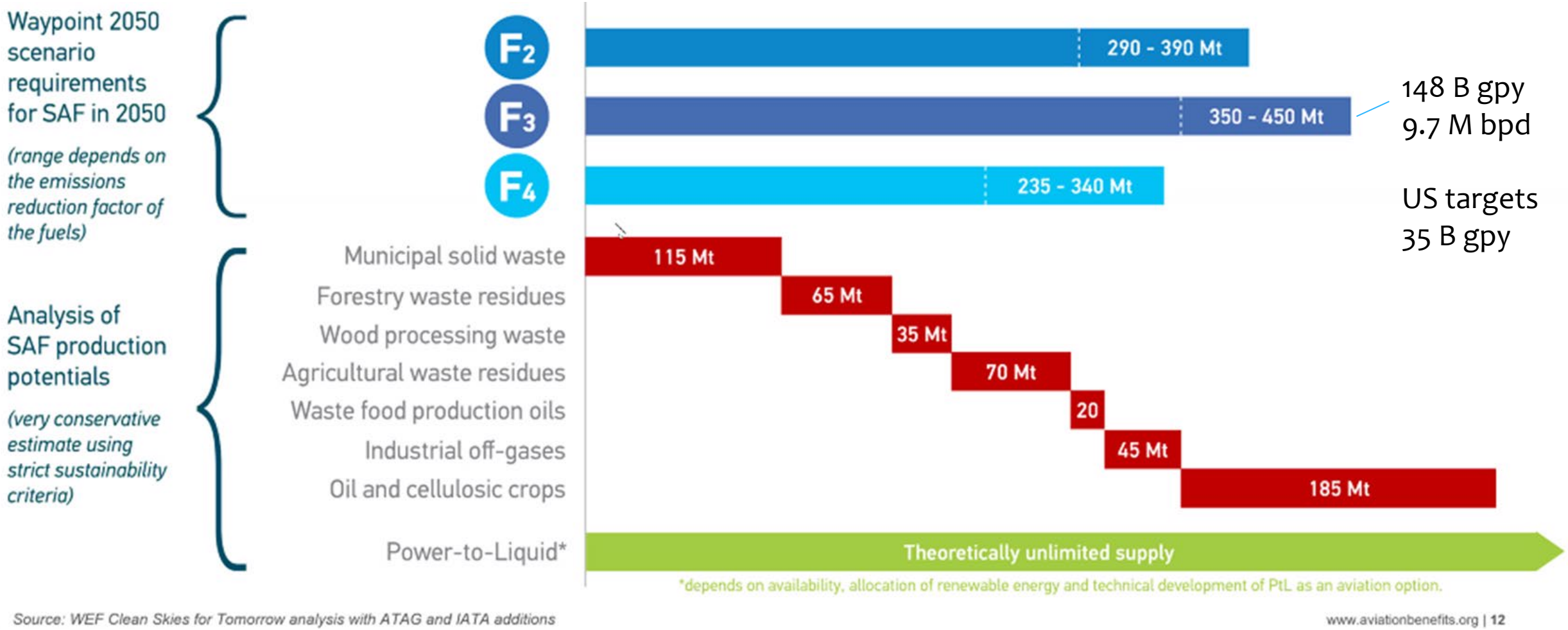
Courtesy of ATAG: https://aviationbenefits.org/media/167417/w2050_v2021_27sept_full.pdf

SAF-production-potential outlook: 2050

Targets of opportunity with low ILUC and affordability



Source: WEF Clean Skies for Tomorrow analysis with ATAG and IATA additions

Overall industry summary on SAF:

SAF are key for meeting industry's commitments on carbon reductions

- Aviation enterprise aligned, representing a 26B gpy US & 97B gpy worldwide opt'y
- Jet fuel demand expected to increase for foreseeable future … 3 - 5% per year (following COVID rebound)
- SAF delivers net GHG reductions of 65-100+%, other enviro services
- Segment knows how to make it; Activities from FRL 1 to 9, with many in "pipeline"
- CAAFI and others are working to foster, catalyze, enable, facilitate, … e.g. SAF Grand Challenge
- First 6 facilities on-line (5 from lipids), increasing run-rates, multiple offtakers
- Commercial agreements being pursued, fostered by policy and other unique approaches
- Pathways identified for fully synthetic SAF (50% max blend today), enhancing SAF value proposition by enabling deeper net-carbon reductions
- Additional work needed on "appropriate conversion process for targeted feedstocks" enabling affordability

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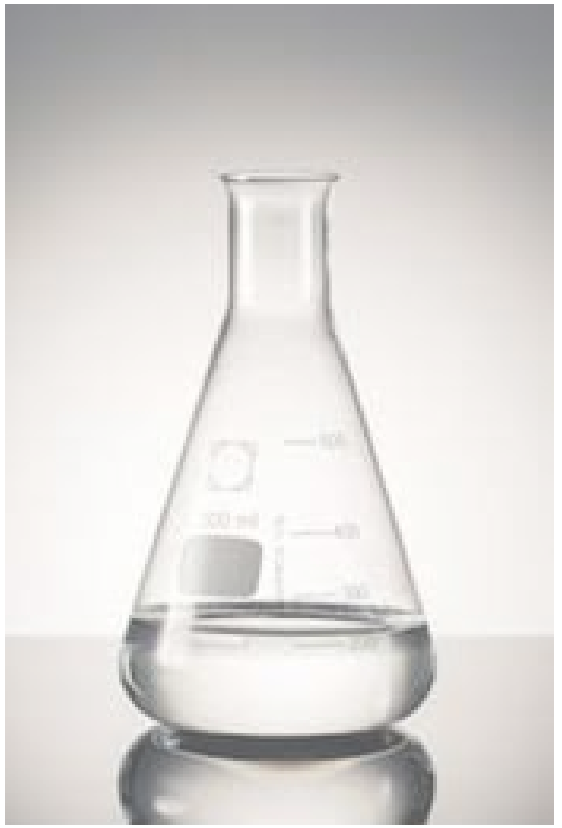


Rik Brouwer

GHG and Market Analyst

tcbiomass – April 19, 2022

SkyNRG

After a decade of voluntary market building, governments are stepping up to create a long-term, stable SAF market

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_2 framework CORSIA framework is expected to cost airlines 3-12 B$ by 2030[1]

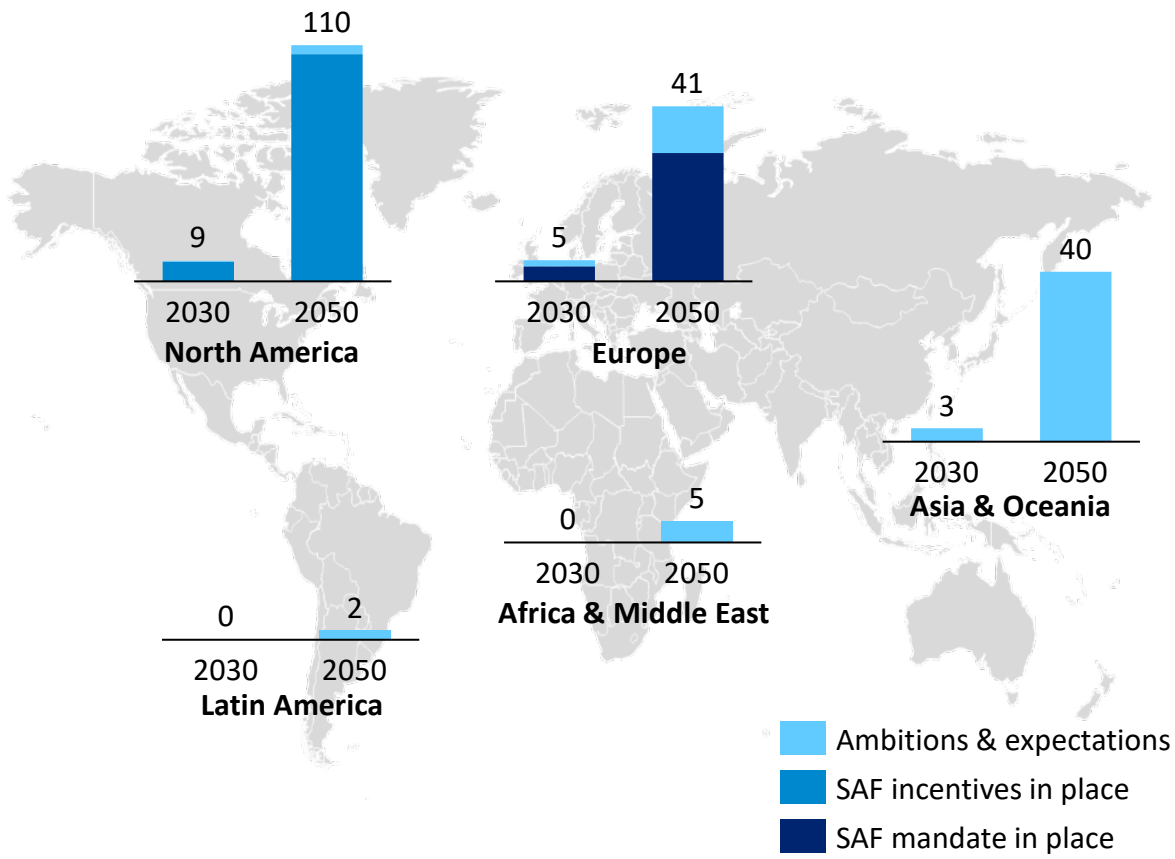
… and voluntary uptake

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 (~2 Mt)
- Delta Airlines: 10% of fuel uptake by 2030 (~1 Mt)
- IAG: 10% of fuel uptake by 2030 (~1 Mt)

SAF demand projected to increase to 17 Mt in 2030 to ~200 Mt in 2050

NB. Graphs denote SAF demand in million metric tonnes (Mt)

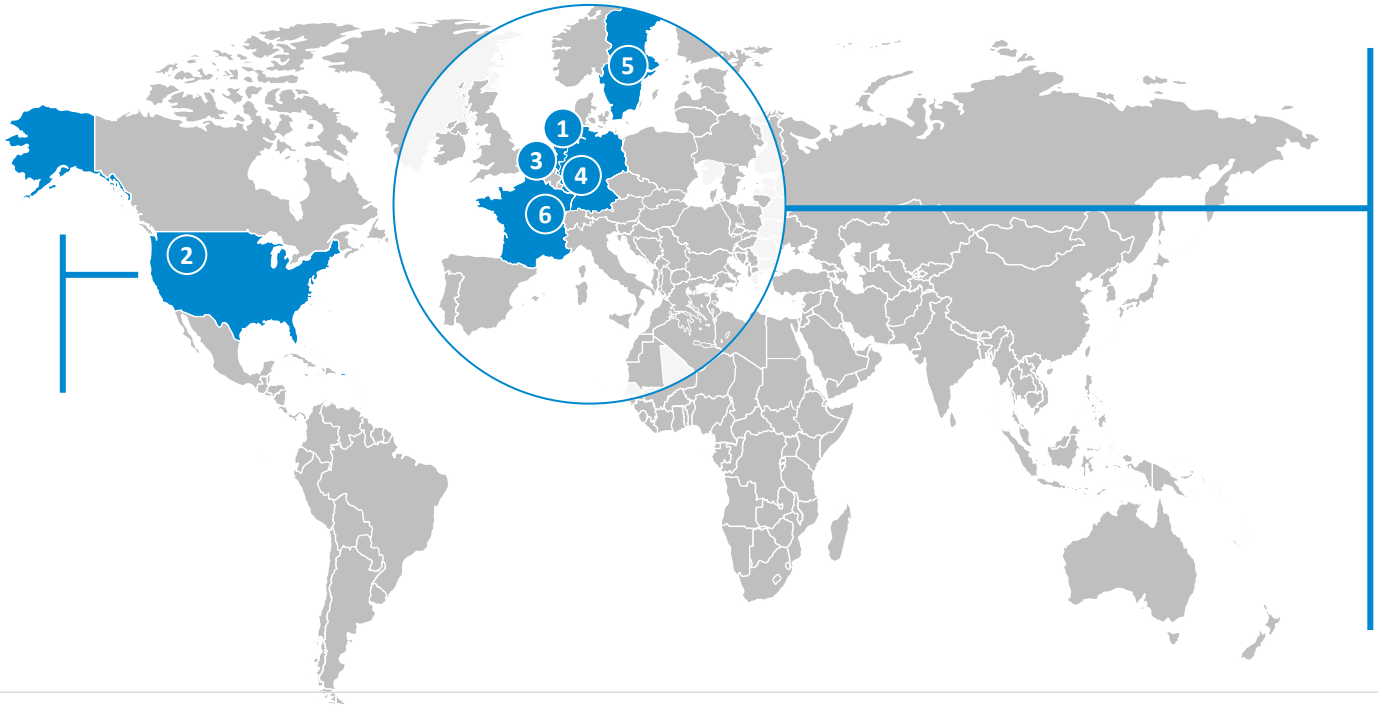


1. Under the CORSIA framework, airlines need to offset emissions to achieve carbon-neutral growth. Source: ATAG Waypoint 2050 (2020), EU ReFuel package (2021), US SAF Grand Challenge (2021), Argus (2020), McKinsey & Company (n.d.), CORSIA (2018), SkyNRG market outlook on SAF (2021), SkyNRG analysis

SkyNRG has an active pipeline of diversified low CI SAF capacity projects in different phases of development across the globe

US SAF capacity project(s)

2 SkyNRG PNW, AtJ technology



European SAF capacity projects

1. DSL-01, HEFA technology + waste oils
3. Synkero, PtL technology
4. Germany, PtL technology
5. Sweden, FT technology + forestry residues
6. France, AtJ technology + agricultural residues

	1 Business development	2 Feasibility & scoping	3 Project scoping/ pre-FEED	4 FEED & permitting	5 Construction and commissioning	Operation
Project development pipeline						
Status of development	Ongoing business development, with ~10 early-stage SAF capacity projects running		Synkero	DSL-01		

Abbreviations: HEFA = Hydroprocessed Esters and Fatty Acids; AtJ = Alcohol-to-Jet; FT = Fischer-Tropsch, PtL = Power-to-Liquids; FEED: Front-end engineering design

SkyNRG

Role of Low Carbon Fuels for Maritime Transport

Jacob Hjerrild Zeuthen
Senior Future Fuels Manager
A.P. Moller – Maersk

MAERSK

TC Biomass, Denver, 19-21 April 2022

We are part of the problem– we want to be part of the solution

Why biofuels?
- In principle, all fuels may be used on a ship
- Realistically, we need carbon-based fuels in the short-term
- All biofuels can be used (and compliment e-fuels)
- Hydrogen only for small ships and ammonia not possible yet

Feedstocks
- Forest residues
- Agricultural residues
- Waste, MSW, lignin, algae (?), digestate from biogas plants…
- Don't use plastic, 1G feedstocks, old forest, palm…

Technologies
- Gasification → methanol → new ships
- Biogas + reforming → methanol → new ships
- Fermentation of 2G biomass → ethanol → new ships
- Lignin + alcohol → new ships
- Thermal conversion; pyrolysis, HTL, Solvolysis…→ existing ships
- Excess CO_2 from biofuels + hydrogen to produce e-fuels

Major challenges
- Overall, short-term: Price for green fuels
- Feedstock availability, handling and pre-treatment
- Biodiversity, who should use the limited biomass?
- Technical challenges; fuel quality, scale-up, regulation
- Fuel sourcing; will there be a market or should we self-supply?

Limit to use of biomass:
- Competition from other sectors: Aviation, road-transport, materials, chemicals- and plastic producers, electricity and heat (BECCS),…
- Who may and who could define the maximal use of biomass?

Maersk and biofuels:
- We are part of a number of projects with professional partners where we try to scale some of the processes for fuel production as well as upgrading the produced biocrudes to marine fuel quality.
- We do evaluate the sustainability of feedstocks but we only buy the fuels
- We invest to accelerate technology development.
- We have leaned forward and challenged the chicken-and-egg dilemma

Maersk presentation: Thursday at 1 pm

MAERSK