CRO Luchthaven Rotterdam cro-rotterdam.nl

Informatiesessie CRO Luchthaven Rotterdam d.d. 11 maart 2026 Sustainable Air Fuel

Tijd: 13.00 – 13.45 uur
Locatie: Raadzaal, Gemeentehuis Lansingerland

Toepassing Sustainable Air Fuel
Vanuit de luchthaven Rotterdam wordt een toelichting gegeven op de ontwikkeling van Sustainable Air Fuel (SAF) in EU en Rotterdam en de test 38% SAF door stichting Rotterdam the Hague Innovation Airport (RHIA). Er is aandacht voor de impact met betrekking tot hinder, praktisch gebruik op de luchthaven en de economische haalbaarheid.

Gespreksleiding
De bijeenkomst wordt geleid door mevrouw Monique List - De Roos, voorzitter van de CRO Luchthaven Rotterdam. Er is ruimte voor dialoog, reflectie en het delen van inzichten tussen de diverse stakeholders.

Informatiebijeenkomst CRO – SAF

Rotterdam The Hague Airport

11 maart 2026

Content

1. **SAF ontwikkelingen: Europees en Mondiaal** – Michelle Samson
2. **SAF op Rotterdam The Hague Airport** – Koen Pouw
3. **Technische verdieping door TU Delft** - Arvind Gangoli Rao

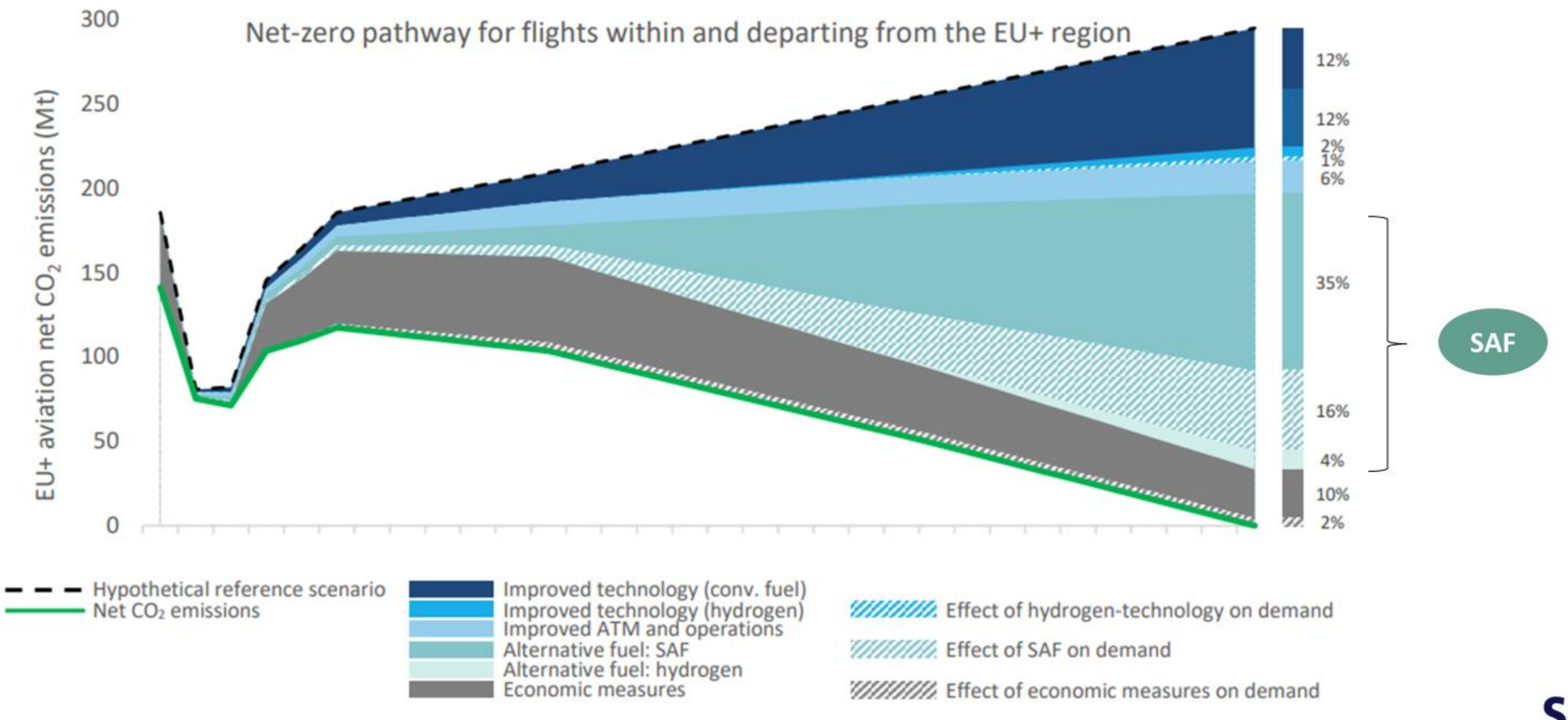
Rotterdam
The Hague
Airport

Wat is Sustainable Aviation Fuel?

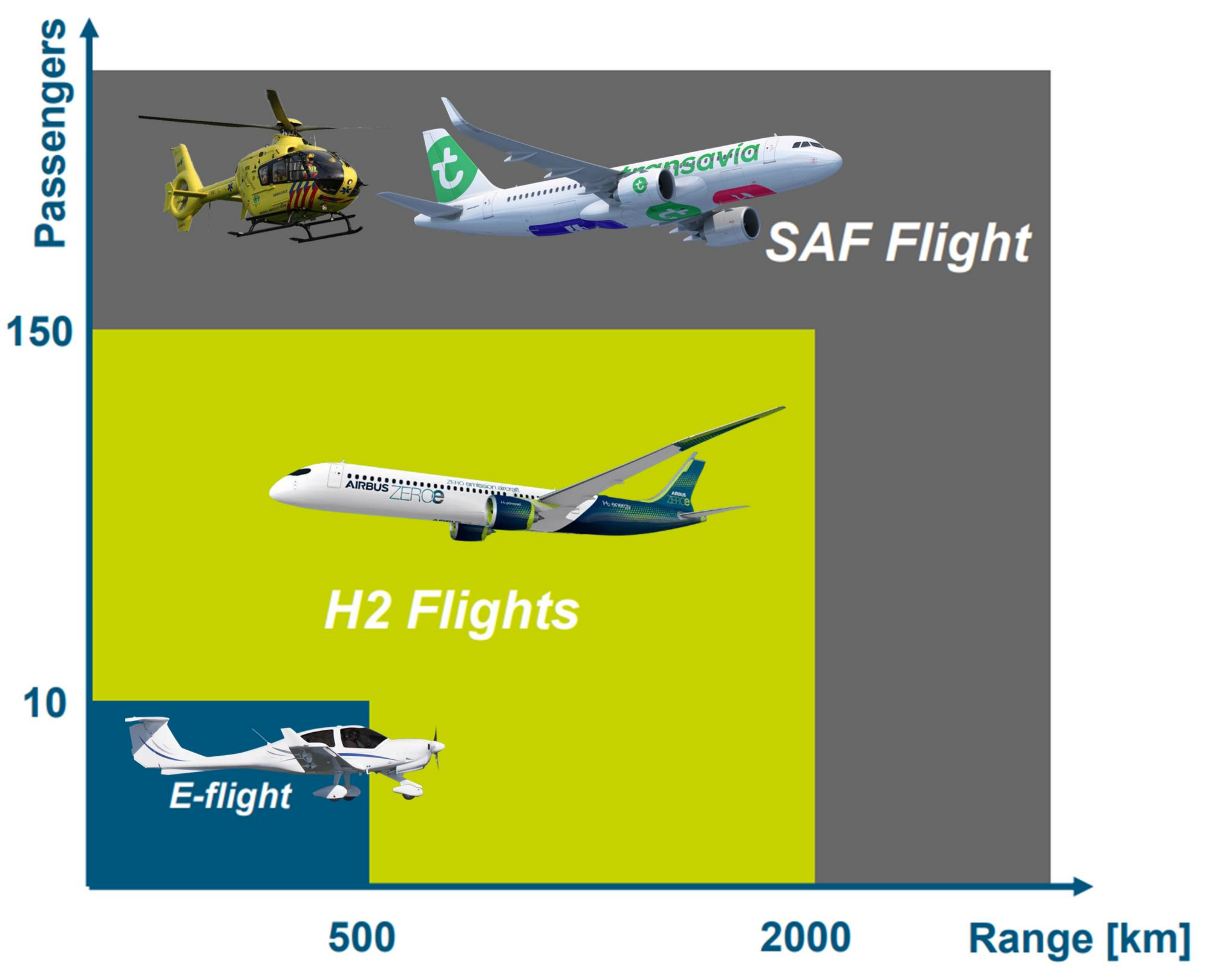
- Sustainable Aviation Fuel (SAF) is een **fossiel-vrije brandstof** die als alternatief voor fossiele kerosine gebruikt kan worden om CO_2-uitstoot van vliegen te verminderen
- SAF wordt gemaakt van **reststromen** zoals gebruikt frituurvet en landbouwafval die aan hoogwaardige duurzaamheidseisen moeten voldoen
- **70 tot 90% minder CO_2-uitstoot** over de volledige levenscyclus (van productie tot gebruik in het vliegtuig) en minder uitstoot van andere stoffen, zoals fijnstof en zwavel
- Kan gemengd worden met fossiele kerosine en is **direct inzetbaar** zonder aanpassingen aan vliegtuigen (tot 50% bijmenging)

Rotterdam The Hague Airport

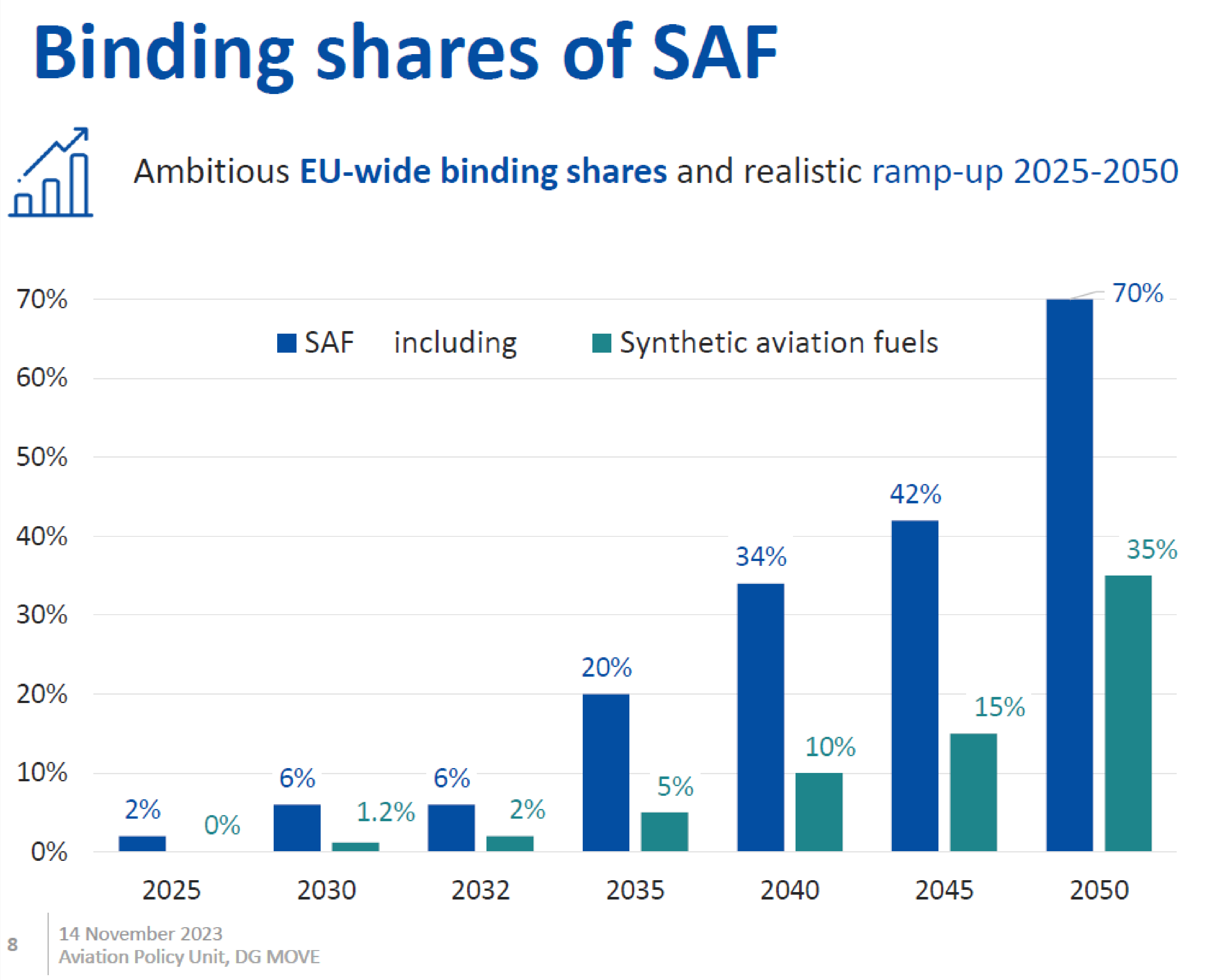
The issue: decarbonizing aviation



Source: Update Destination 2050, 2024



Alle sporen van de energietransitie in de lucht zijn nodig, inzet van SAF is vandaag al mogelijk



Binding shares of SAF

Ambitious **EU-wide binding shares** and realistic ramp-up 2025-2050

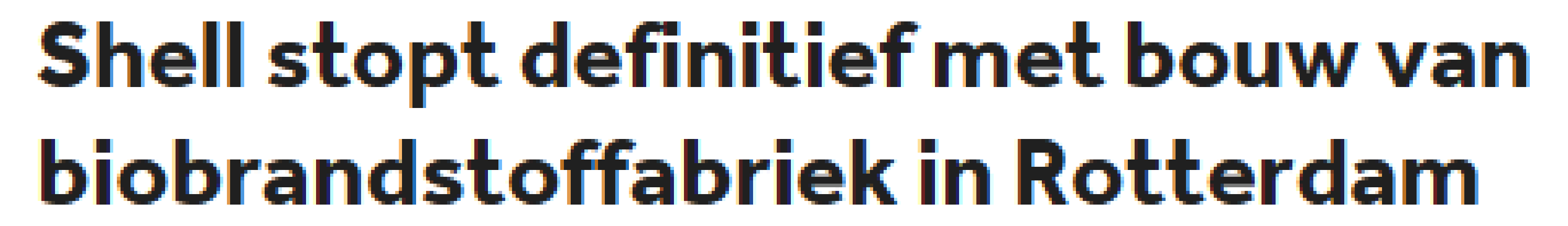
8

14 November 2023
Aviation Policy Unit, DG MOVE

Sinds 2025 geldt er een Europese bijmengverplichting van SAF

Brandstofleveranciers moeten tot 2030 minimaal 2% SAF bijmengen, oplopend tot 70% in 2050

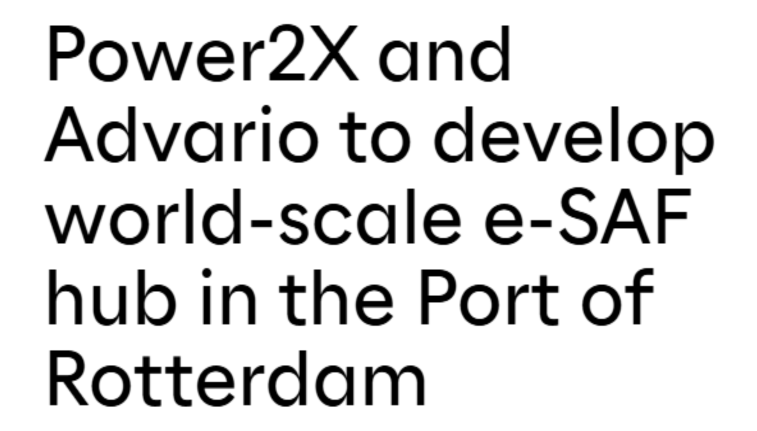
SAF update PoR

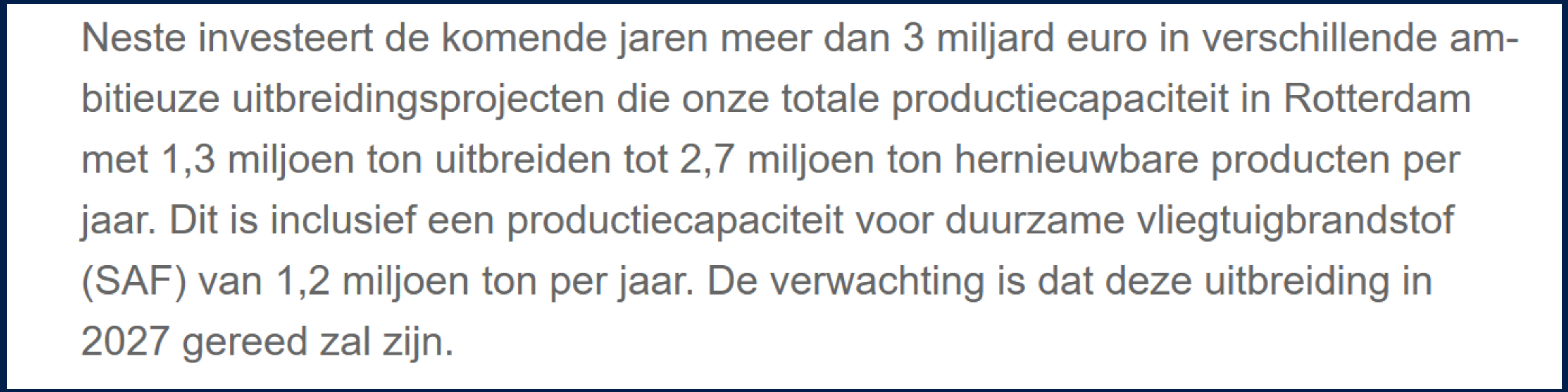

Shell stopt definitief met bouw van biobrandstoffabriek in Rotterdam


Metafuels en Evos werken samen om de productie van e-SAF in Rotterdam te versnellen


Fins UPM trekt stekker uit bouw biobrandstoffenfabriek Rotterdam

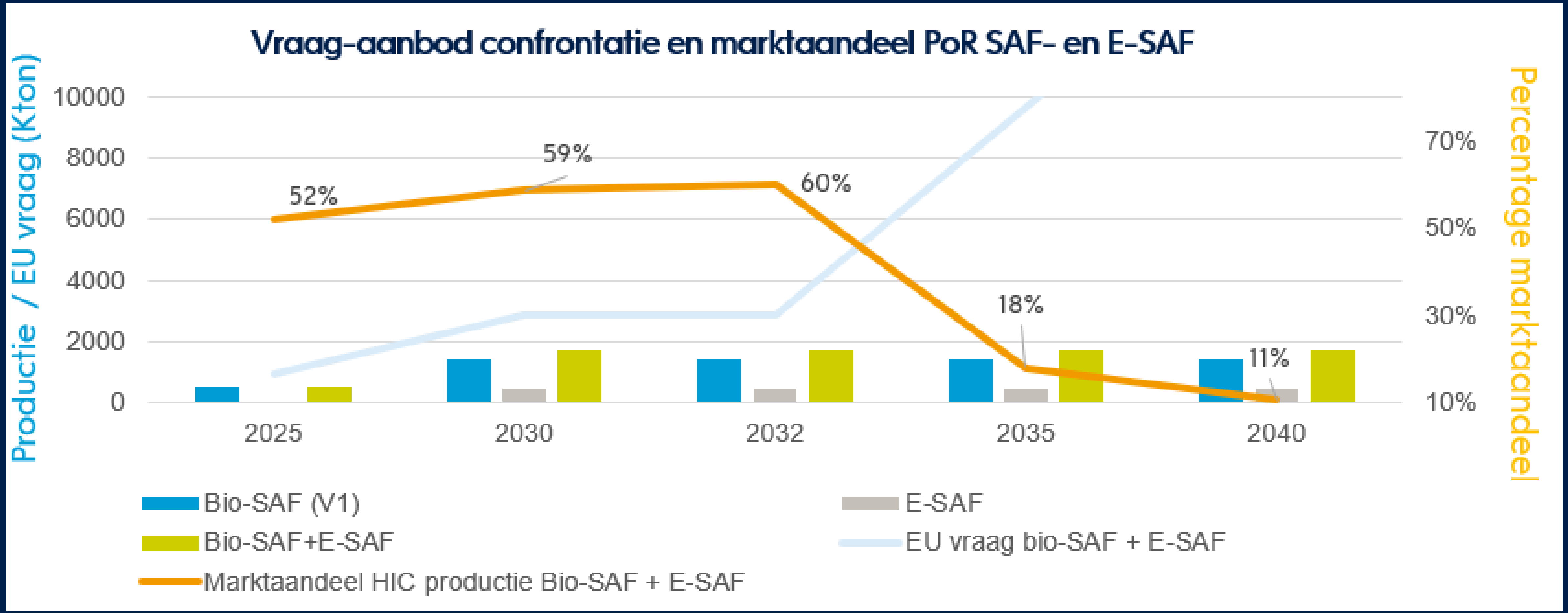

Ook BP stopt met bouw van biobrandstoffenfabriek in haven Rotterdam

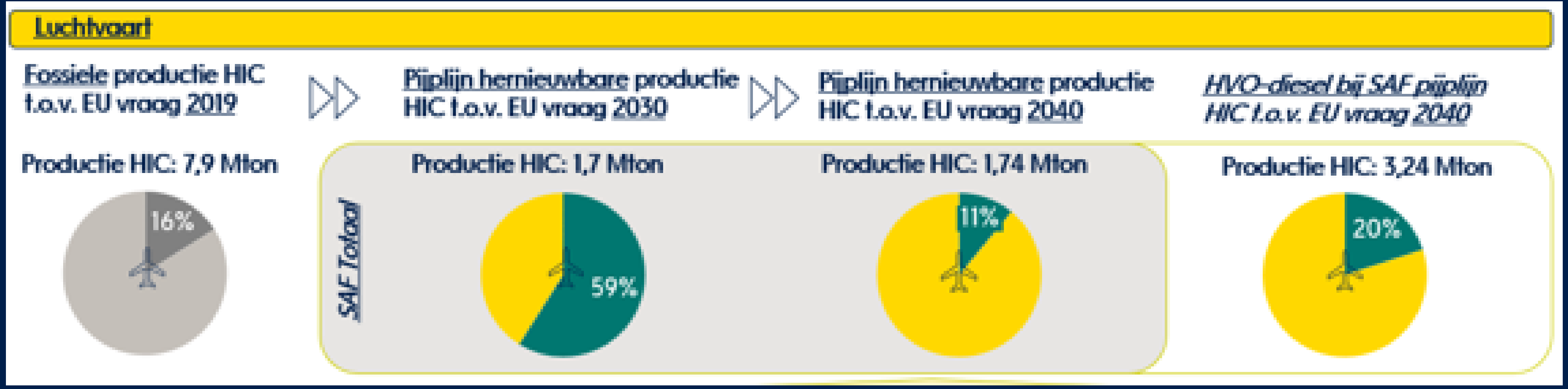

Power2X and Advario to develop world-scale e-SAF hub in the Port of Rotterdam


Neste investeert de komende jaren meer dan 3 miljard euro in verschillende ambitieuze uitbreidingsprojecten die onze totale productiecapaciteit in Rotterdam met 1,3 miljoen ton uitbreiden tot 2,7 miljoen ton hernieuwbare producten per jaar. Dit is inclusief een productiecapaciteit voor duurzame vliegtuigbrandstof (SAF) van 1,2 miljoen ton per jaar. De verwachting is dat deze uitbreiding in 2027 gereed zal zijn.


SkyNRG start bouw fabriek voor duurzame vliegtuigbrandstof

SAF update PoR





2030 - 2040:

→Vraag groeit sterk door bijmengverplichting 34% (waarvan 10% e-SAF)

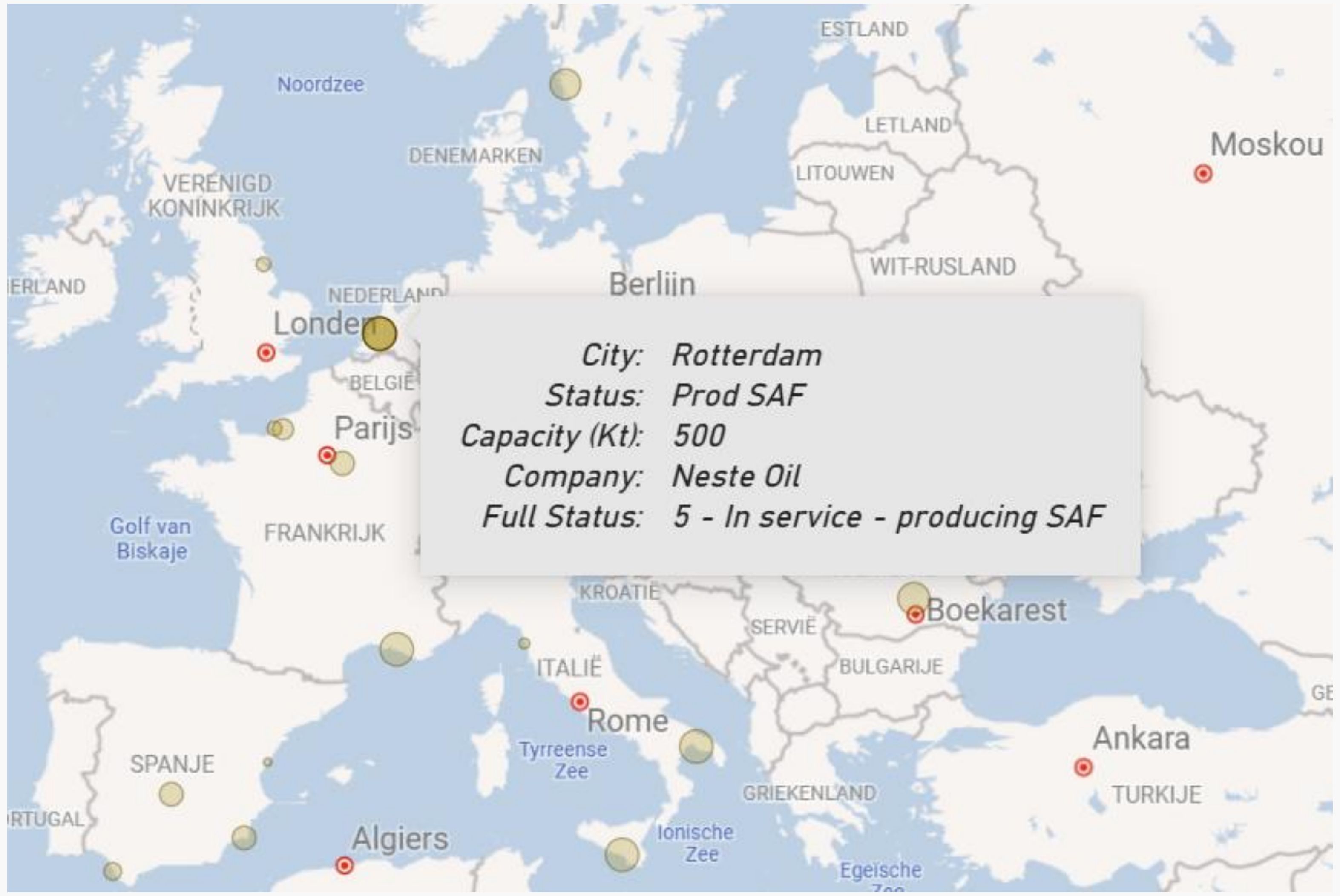
→Zonder extra investeringen zakt marktaandeel van 59% (2030) naar 11% in 2040

→**Boodschap RTM: ‘Europees SAF-knooppunt’**

Behoefte aan:

- Behoud huidige partijen
- Nieuwe bio-SAF producent
- Minimaal twee grote e-SAF producenten
- Voldoende feedstock beschikbaar (biomass en e-methanol)
- Lobby evt aanscherping EU mandaten
- Toegankelijkheid CEPS

SAF productie wereldwijd



City: Rotterdam
Status: Prod SAF
Capacity (Kt): 500
Company: Neste Oil
Full Status: 5 - In service - producing SAF

Source: ICAO

SAF op Rotterdam The Hague Airport

Nederlandse SAF ambities

- Akkoord Duurzame Luchtvaart 2019: **14% SAF in 2030**
- Ondertekend door Nederlandse luchtvaartbedrijven, overheid en kennisinstellingen
- **Nederlandse ambitie liggen hoger** dan het Europese mandaat van ReFuelEU

- RTHA heeft een poging gedaan om dit gat te dichten middels een **vrijwillige bijmenging** van SAF voor airlines en het zakelijke segment → 2025: 3% SAF (1% extra boven de verplichting)

Rotterdam
The Hague
Airport

Pathway
Future energy supply (chain)
Developing the airport infrastructure and operational processes for hydrogen-powered, SAF and battery-electric flights.

Pathway
Smart energy airport
Developing smart energy systems to manage current and future airport energy demand with sustainable solutions.

Pathway
Environmental & societal impact
Optimising flight paths to reduce noise and emissions, improving air quality with cleaner fuels and reducing waste.

EXECUTIVE BOARD

Rotterdam The Hague Airport

nlr

TU Delft

Opzet

- RHIA project i.s.m. TU Delft, Shell en Jet Aviation
- 38% fysieke bijmengen van SAF tijdens practicum vluchten

Doel

- Onderzoeken van emissies (CO_2, NO_x en lokale luchtkwaliteit) en vorming van condensstrepen door hogere SAF bijmenging
- Ervaring opdoen in het opzetten van een aparte toeleveringsketen voor SAF met hogere bijmenging

Resultaten – Q2 2026

- Significante verandering in uitstoot van NO_x en fijnstof door hogere SAF bijmenging
- Geen negatieve impact op motorprestaties en brandstofverbruik

Meer resultaten tijdens RHIA SAF Talk: mei/juni 2026

Sustainable Aviation Fuels: Challenges & Opportunities

Prof. Dr. Arvind Gangoli Rao
Professor and Chair of Sustainable Aircraft Propulsion
Faculty of Aerospace Engineering, TU Delft

Environmental effects of aircraft emissions

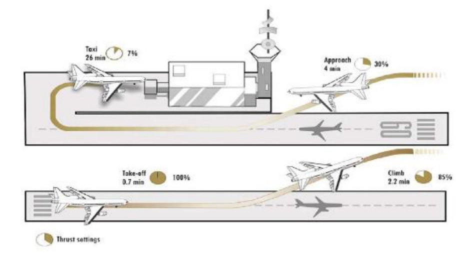
Stratosphere (>17km)
- NO_x
- H_2O

Climate change; Ozone layer

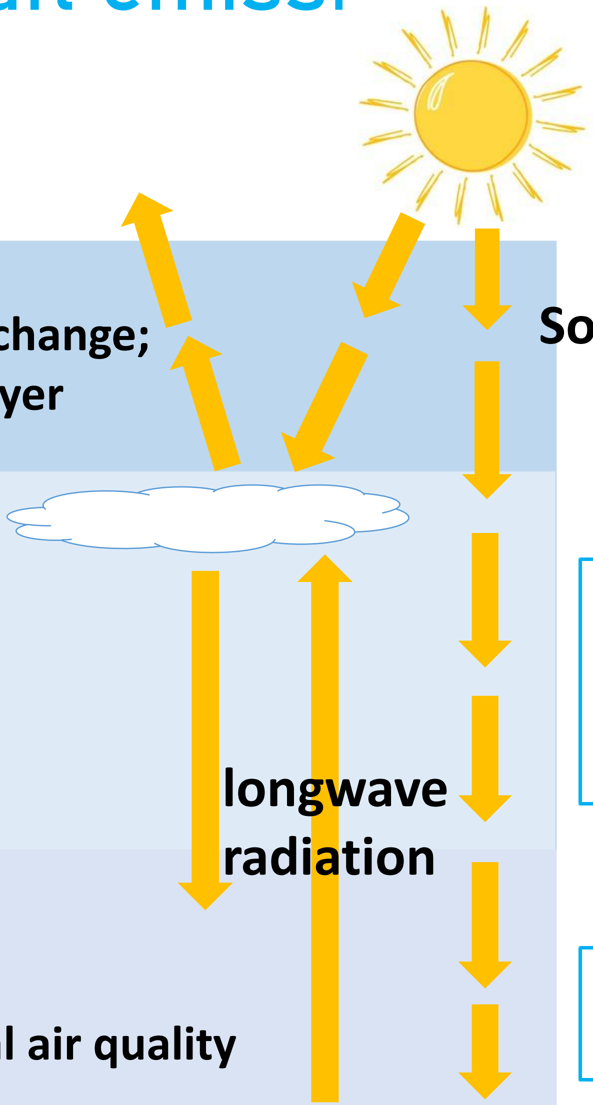
Troposphere (9 – 13 km)
- Contrail cirrus
- CO_2
- NO_x
- H_2O
- Particulate matters

Climate change

Ground level (<3000 feet)
- NO_x
- Particulate Matters
- Noise



Local air quality



Solar radiation

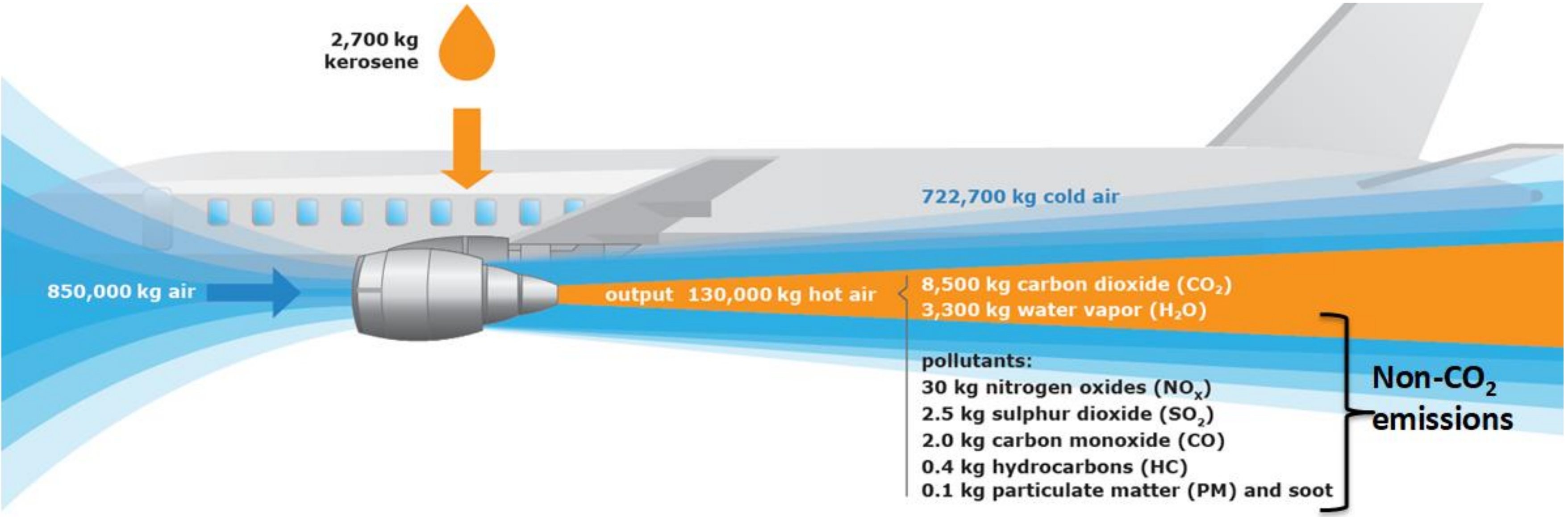
longwave radiation

Anually aviation is responsible for around 1 billion tonnes of CO_2, **2.5% of global CO_2** emission and around **4 % of global warming**

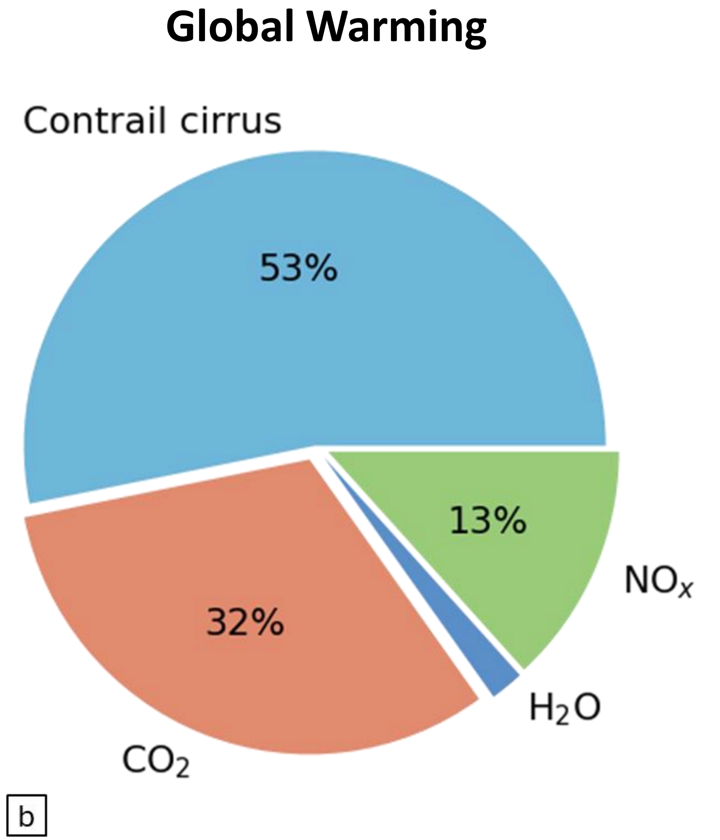
In NL, **aviation** is responsible for more **8%** of the total **CO_2** emissions

2

Aircraft Emissions



Emissions from a typical two-engine jet aircraft during 1-hour flight with 150 passengers (Source: FOCA)



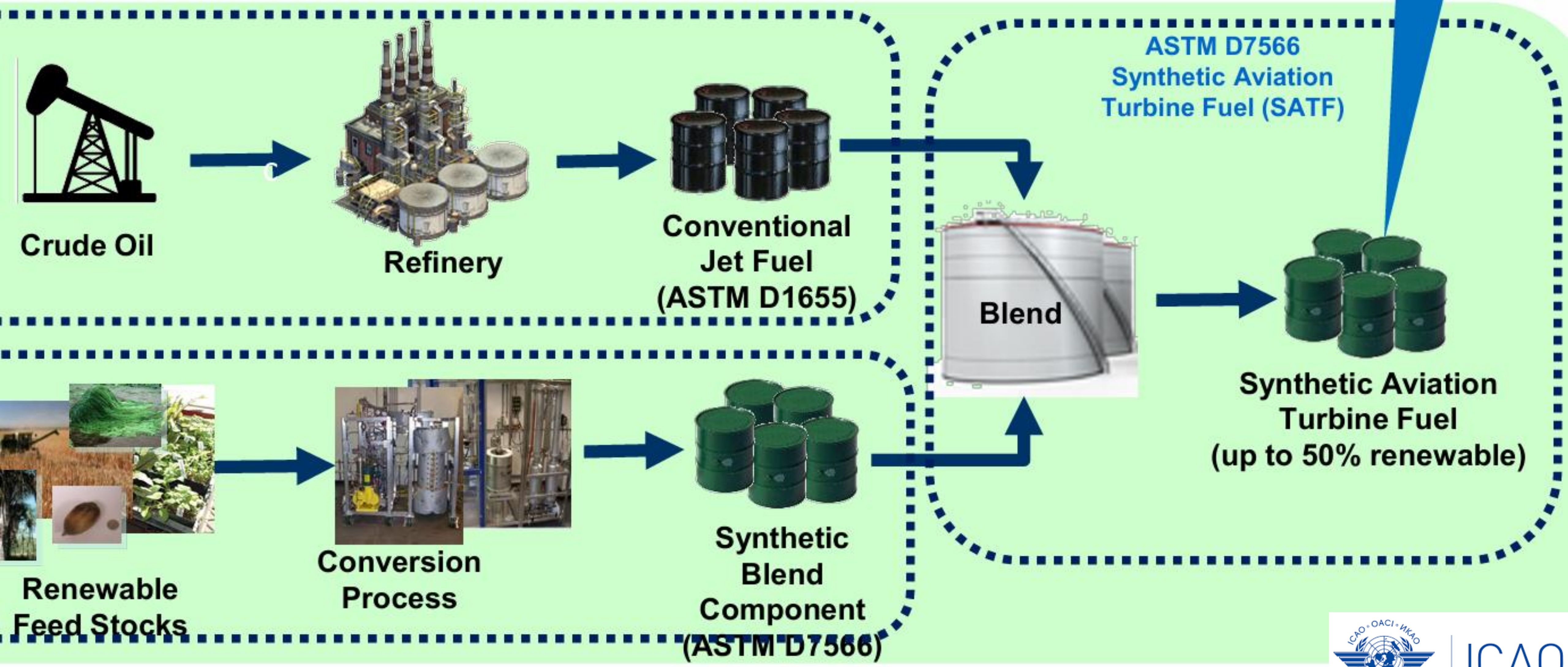
Feijia Yin, Castino, 2024,.
Figure dapted from Table 2 and Figure 3 of Lee et al., 2021.

SAF

A synthetic substitute for kerosene with similar physical and chemical properties

Current D7566 SATF Production Concept

This **IS**
Jet A/Jet
A-1 Fuel



Crude Oil

Refinery

Conventional
Jet Fuel
(ASTM D1655)

Renewable
Feed Stocks

Conversion
Process

Synthetic
Blend
Component
(ASTM D7566)

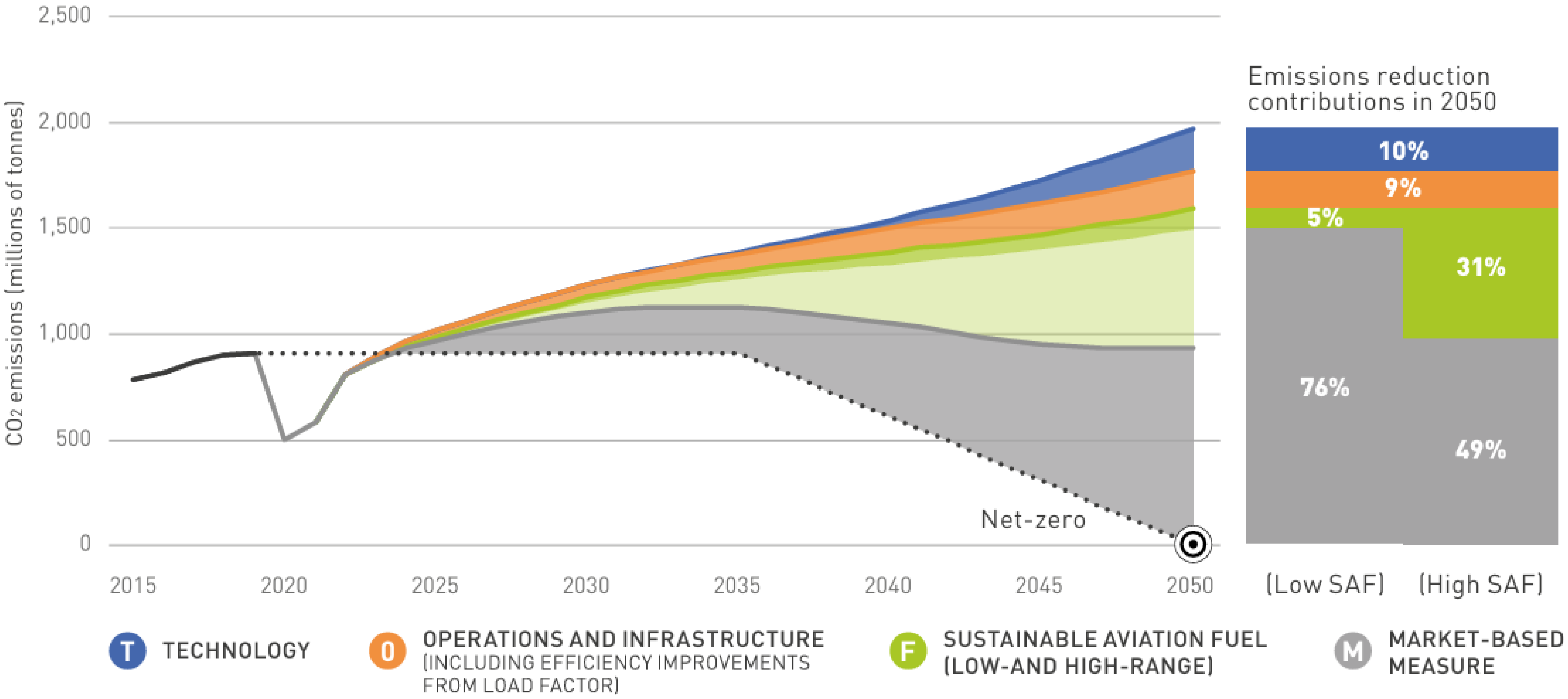
ASTM D7566
Synthetic Aviation
Turbine Fuel (SATF)

Blend

Synthetic Aviation
Turbine Fuel
(up to 50% renewable)

ICAO

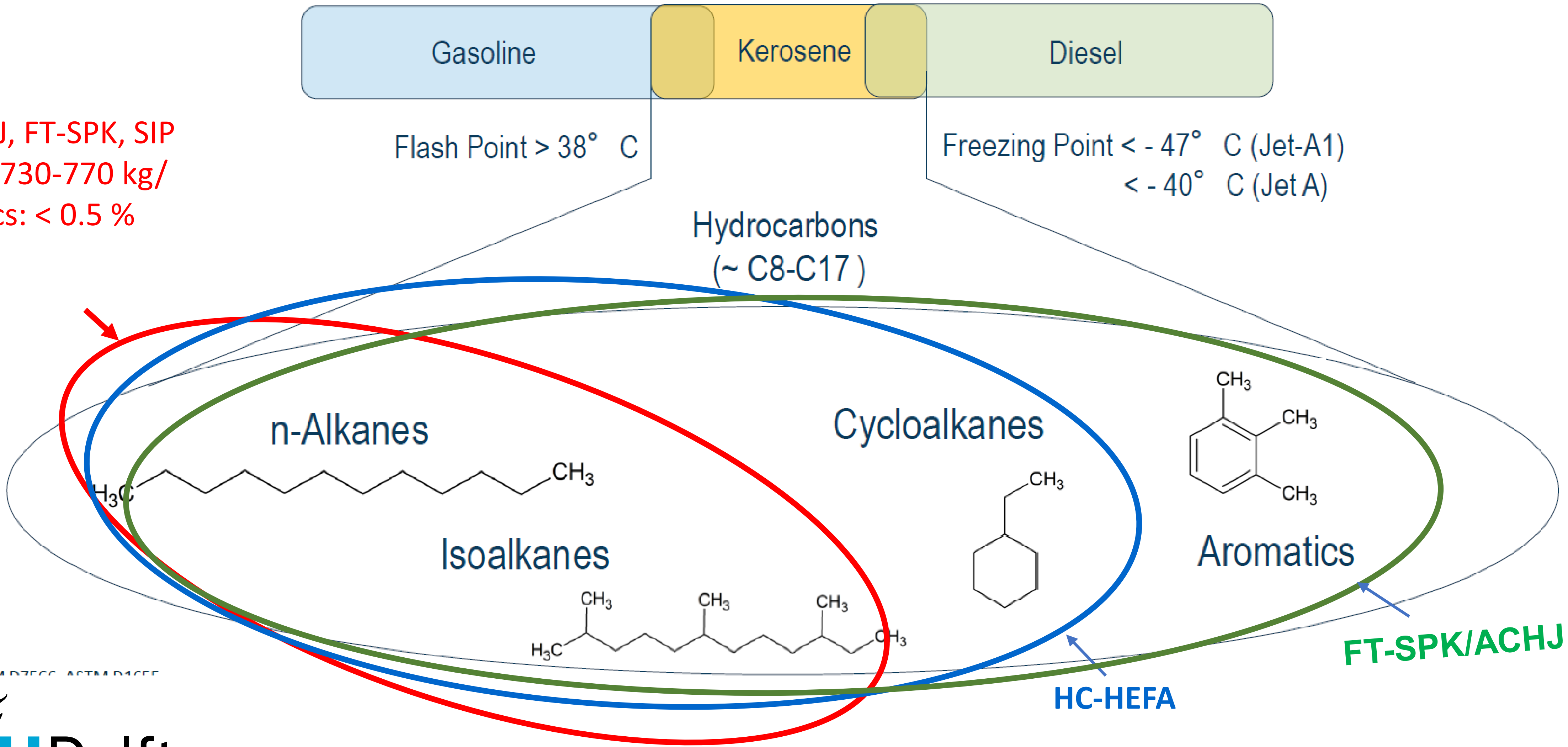
SAF will play an important role in sustainability



Sources: ATAG, Waypoint 2050, 2021

Jet A and SAF

HEFA, AtJ, FT-SPK, SIP
Density: 730-770 kg/
Aromatics: < 0.5 %



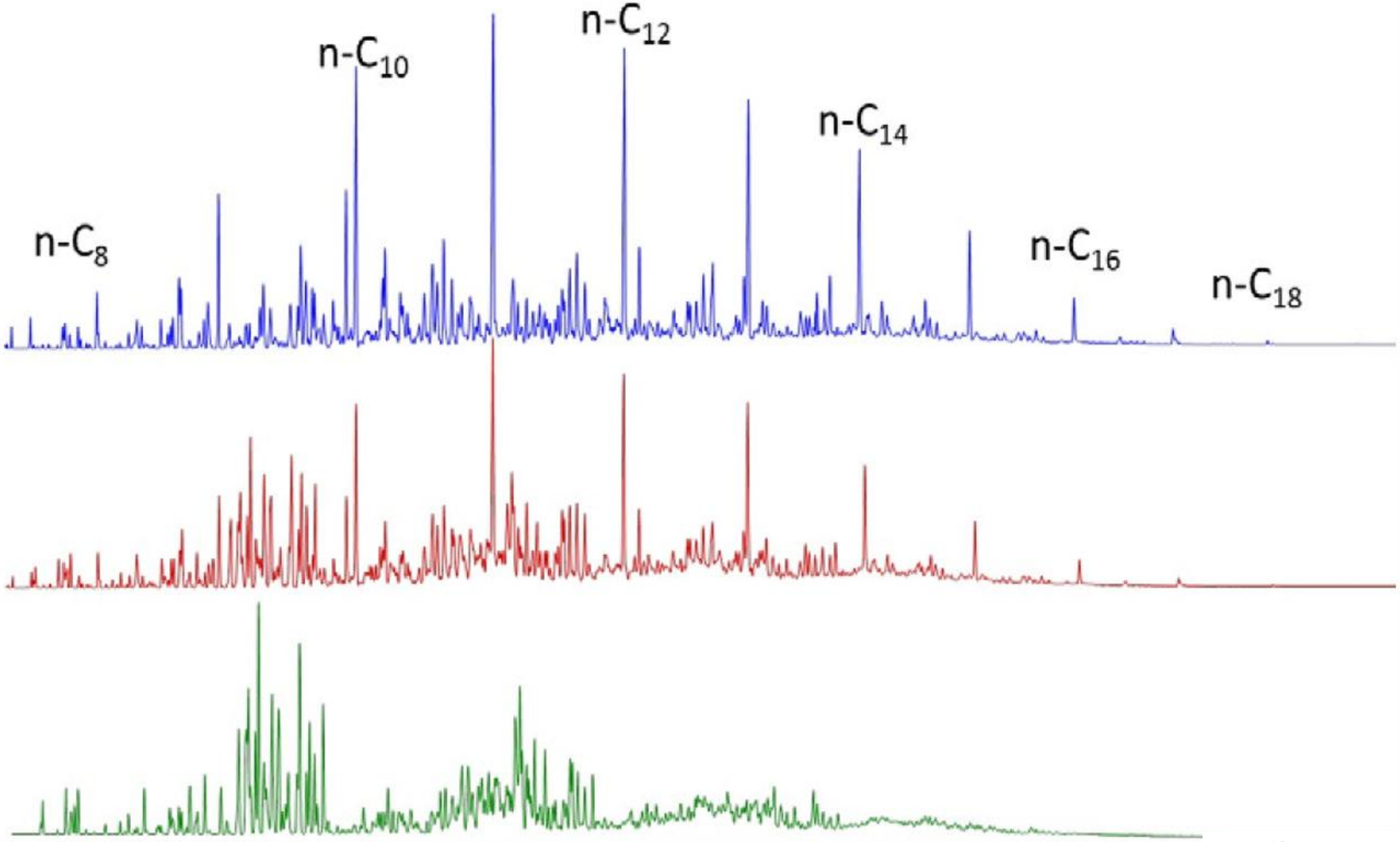
ASTM D7566, ASTM D1655See www.caafi.org/focus_areas/fuel_qualification.html for description of all approved fuel pathways

Why SAF is always blended?

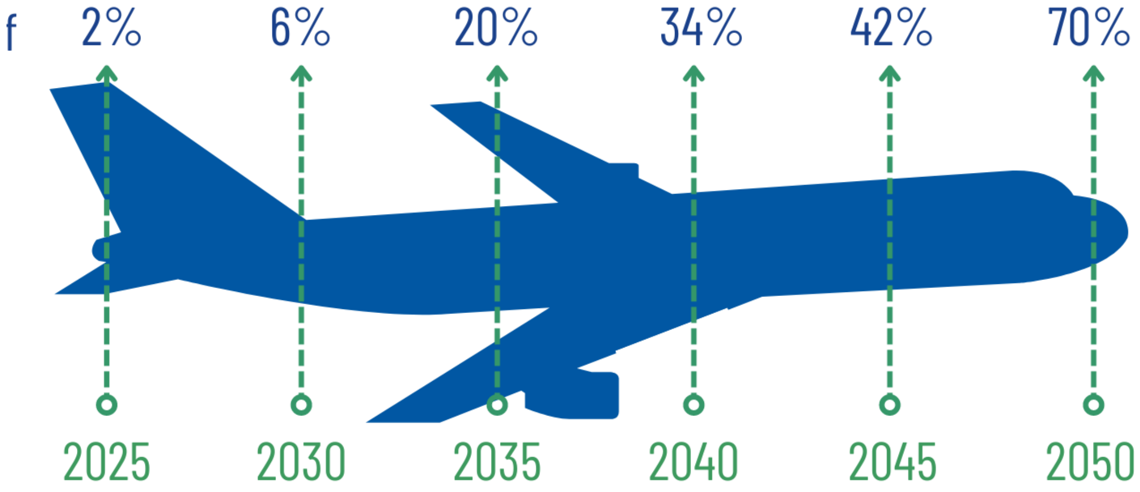
Aviation Turbine fuel (ATF)
100% petroleum
(Approved for flight)

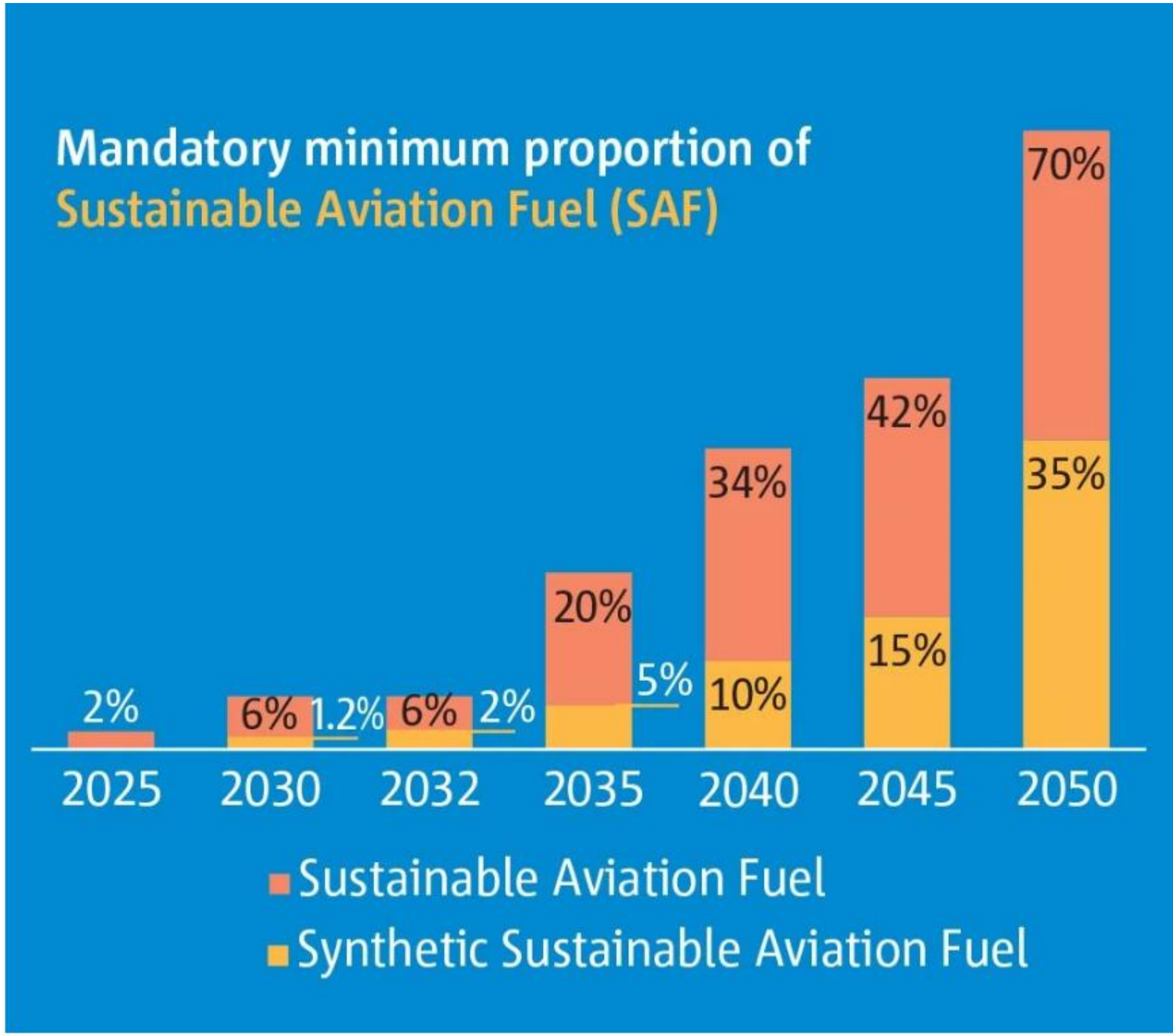
SATF = ATF+SBC
(Approved for flight)

100% SBC
(Synthetic
Blend Component)
Not approved for flight



ReFuel EU





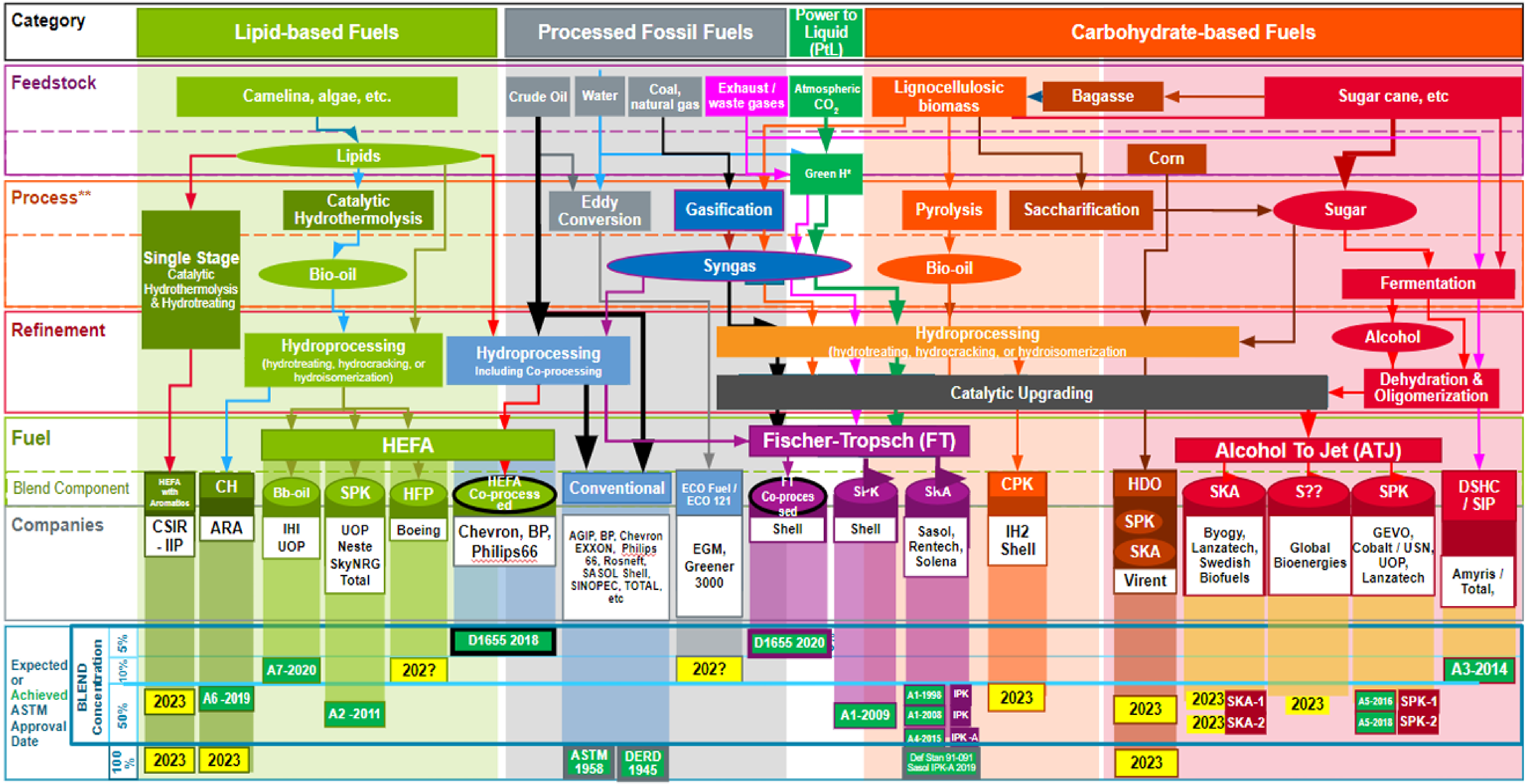
Source: SAF Policy Actions | EASA

ASTM approved SAF processes

Pathway	Approved Name	Blending Limitation	Feedstocks	Chemical Process
Fischer-Tropsch (FT) Synthetic Paraffinic Kerosene (SPK)	FT-SPK, ASTM D7566 Annex A1, 2009	**50%**	Municipal solid waste, agricultural and forest wastes, energy crops	Woody biomass is converted to syngas using gasification, then a Fischer-Tropsch synthesis reaction converts the syngas to jet fuel. ASTM approved in June 2009 with a 50% blend limit.
Hydroprocessed Esters and Fatty Acids	HEFA-SPK, ASTM D7566 Annex A2, 2011	**50%**	Oil-based feedstocks (e.g., jatropha, algae, camelina, and yellow grease)	Triglyceride feedstocks such as plant oil; animal oil; yellow or brown greases; or waste fat, oil, and greases are hydroprocessed to break apart the long chain of fatty acids, followed by hydroisomerization and hydrocracking. This pathway produces a drop-in fuel and was ASTM approved in July 2011 with a 50% blend limit.
Hydroprocessed Fermented Sugars to Synthetic Isoparaffins	HFS-SIP, ASTM D7566 Annex A3, 2014	**10%**	Sugars	Microbial conversion of sugars to hydrocarbons. Feedstocks include cellulosic biomass feedstocks (e.g., herbaceous biomass and corn stover). Pretreated waste fat, oil, and greases also can be eligible feedstocks. ASTM approved by ASTM in June 2014 with a 10% blend limit.
FT-SPK with Aromatics	FT-SPK/A, ASTM D7566 Annex A4, 2015	**50%**	Same as A1	Biomass is converted to syngas, which is then converted to synthetic paraffinic kerosene and aromatics by FT synthesis. This process is similar to FT-SPK ASTM D7566 Annex A1, but with the addition of aromatic components. ASTM approved in November 2015 with a 50% blend limit.
Alcohol-to-Jet Synthetic Paraffinic Kerosene	ATJ-SPK, ASTM D7566 Annex A5, 2016	**50%**	Cellulosic biomass	Conversion of cellulosic or starchy alcohol (isobutanol and ethanol) into a drop-in fuel through a series of chemical reactions—dehydration, hydrogenation, oligomerization, and hydrotreatment. Ethanol and isobutanol produced from lignocellulosic biomass (e.g., corn stover) are considered favorable feedstocks. ASTM approved in April 2016 for isobutanol and in June 2018 for ethanol with a 30% blend limit.
Catalytic Hydrothermolysis Synthesized Kerosene	CH-SK or CHJ, ASTM D7566 Annex A6, 2020	**50%**	Fatty acids or fatty acid esters or lipids from fat oil greases	(Also called hydrothermal liquefaction), clean free fatty acid oil from processing waste oils or energy oils is combined with preheated feed water and then passed to a catalytic hydrothermolysis reactor. Feedstocks for the CH-SPK process can be a variety of triglyceride-based feedstocks such as soybean oil, jatropha oil, camelina oil, carinata oil, and tung oil. ASTM approved in February 2020 with a 50% blend limit.
Hydrocarbon-Hydroprocessed Esters and Fatty Acids	HC-HEFA-SPK, ASTM D7566 Annex A7, 2020	**10%**	Algal oil	Conversion of the triglyceride oil, derived from Botryococcus braunii, into jet fuel and other fractionations. Botryococcus braunii is a high-growth alga that produces triglyceride oil. ASTM approved in May 2020 with a 10% blend limit.
Fats, Oils, and Greases (FOG) Co-Processing	FOG Co-Processing ASTM D1655 Annex A1	**5%**	Fats, oils, and greases	ASTM approved 5% fats, oils, and greases coprocessing with petroleum intermediates as a potential SAF pathway. Used cooking oil and waste animal fats are two other popular sources for coprocessing.
FT Co-Processing	FT Co-Processing ASTM D1655 Annex A1	**5%**	FT biocrude	In association with the University of Dayton Research Institute, ASTM approved 5% Fischer-Tropsch syncrude coprocessing with petroleum crude oil to produce SAF.

Alternative Fuels Data Center: Sustainable Aviation Fuel

Current Scenario



* Green H = Hydrogen produced from renewable energy sources e.g. wind/solar/hydro

** Process / information is shown for diagrammatic purposes only

*** A1, A2, A3, A4, A5, A6, A7 refer to ASTM D7566 annexes

**** Dates are estimations only, as of October 2022

SAF at a Glance

There are 9 approved (ASTM-certified) pathways currently

SAF currently accounts for only 0.7 % of global aviation fuel demand

SAF costs 3 to 5 times more than conventional jet fuel

A comprehensive well-to-wake climate impact assessment of sustainable aviation fuel, L Boerboom, A. Gangoli Rao, V Grewe, F Yin, Scientific Reports 15 (1), 31966

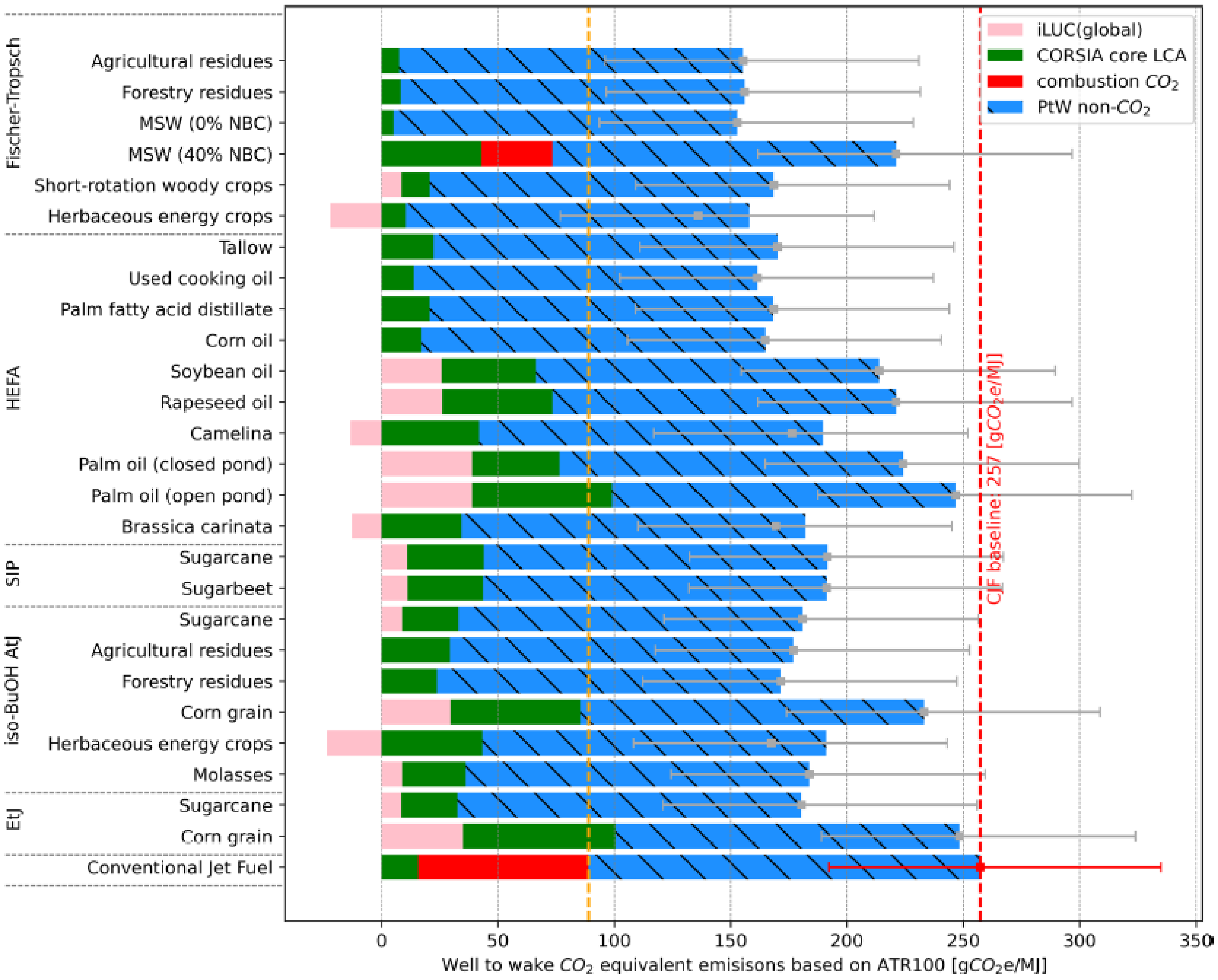
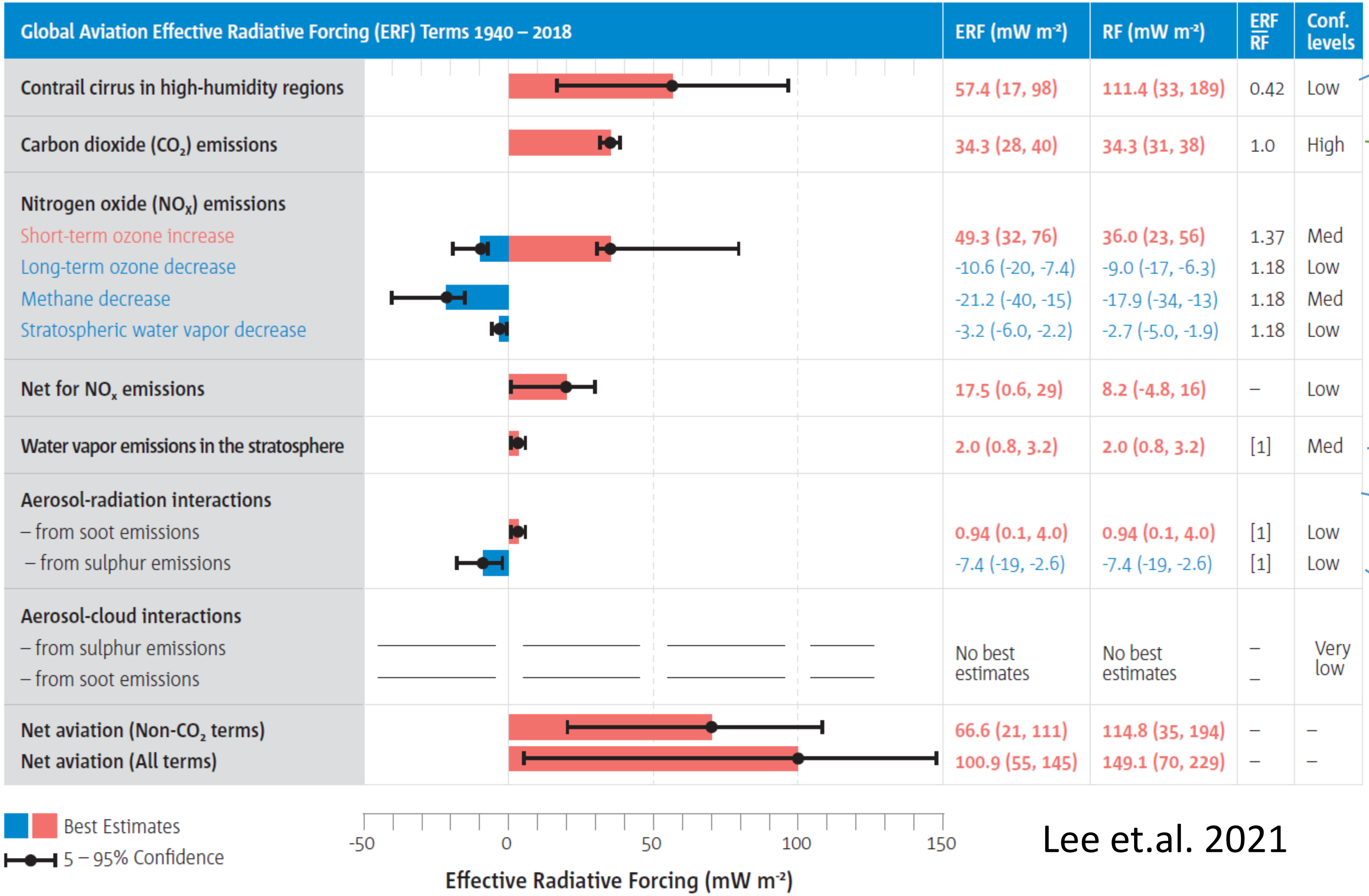


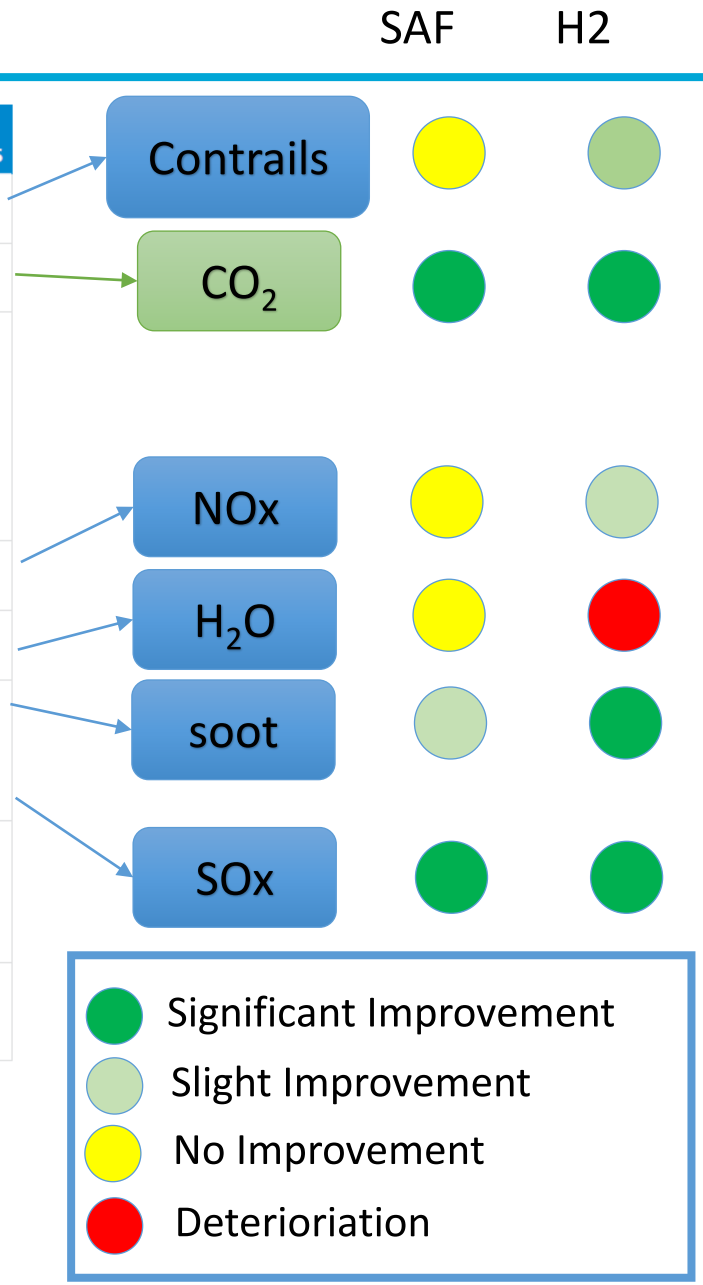
Fig. 3. The estimated well-to-wake LCCIA CO_{2e} emissions in gCO_2e/MJ based on the core lifecycle emissions values for CORSIA Eligible Fuels and conventional jet fuel[24]. Induced Land Use Change values (iLUC in pink) are the global values taken from CORSIA[24]. The PtW non-CO_2 contribution is based on the ATR100. Error bars denote 5–95% confidence intervals based on a Monte Carlo analysis with 2000 simulations. NBC = Non-Biogenic Carbon. MSW = Municipal Solid Waste. HEFA = Hydrotreated Esters and Fatty Acids. SIP = Synthesized Iso-Paraffins. AtJ = Alcohol to Jet. EtJ = Ethanol to Jet.

Climate Impact of Aviation



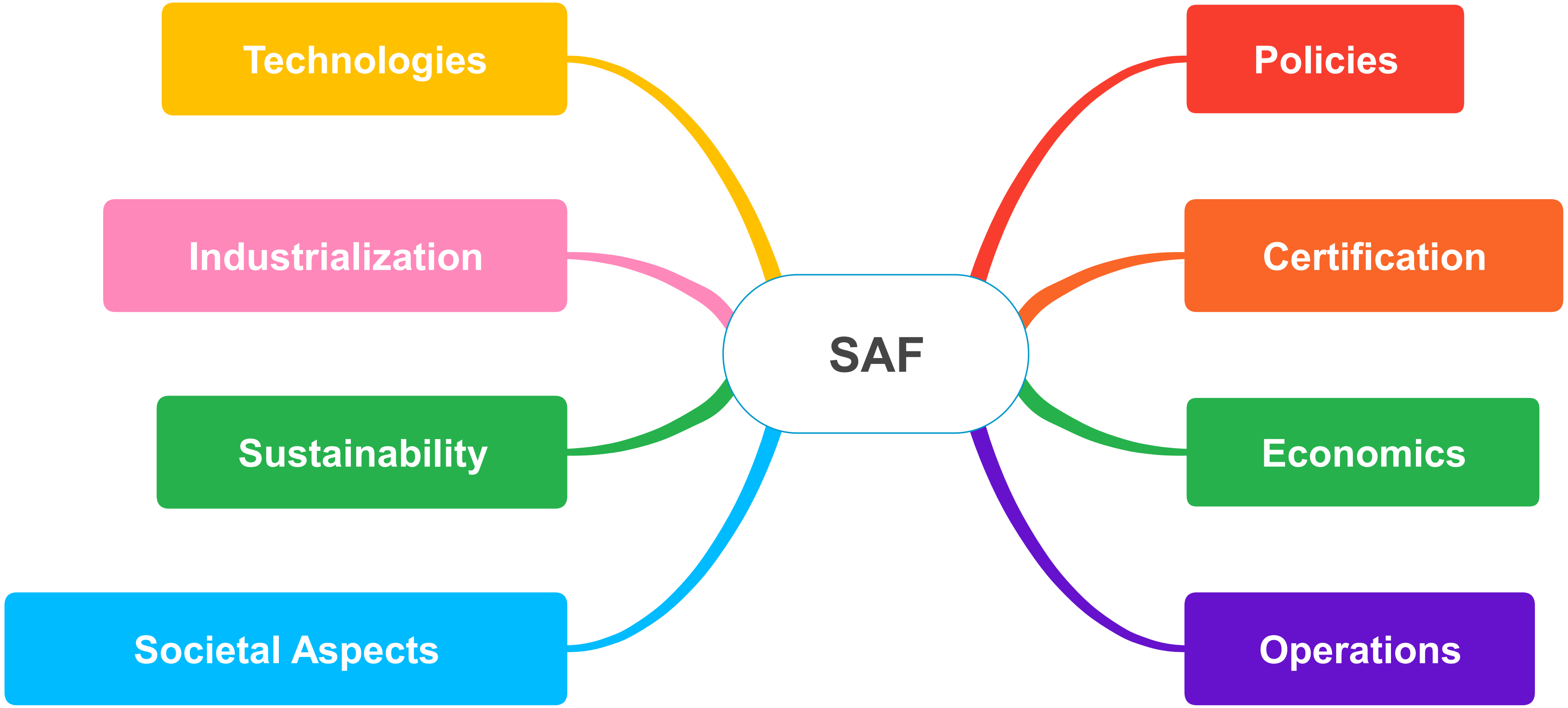
Global Aviation Effective Radiative Forcing (ERF) Terms 1940 – 2018	ERF (mW m⁻²)	RF (mW m⁻²)	ERF/RF	Conf. levels
Contrail cirrus in high-humidity regions	57.4 (17, 98)	111.4 (33, 189)	0.42	Low
Carbon dioxide (CO_2) emissions	34.3 (28, 40)	34.3 (31, 38)	1.0	High
Nitrogen oxide (NO_x) emissions				
Short-term ozone increase	49.3 (32, 76)	36.0 (23, 56)	1.37	Med
Long-term ozone decrease	-10.6 (-20, -7.4)	-9.0 (-17, -6.3)	1.18	Low
Methane decrease	-21.2 (-40, -15)	-17.9 (-34, -13)	1.18	Med
Stratospheric water vapor decrease	-3.2 (-6.0, -2.2)	-2.7 (-5.0, -1.9)	1.18	Low
Net for NO_x emissions	17.5 (0.6, 29)	8.2 (-4.8, 16)	–	Low
Water vapor emissions in the stratosphere	2.0 (0.8, 3.2)	2.0 (0.8, 3.2)	[1]	Med
Aerosol-radiation interactions				
– from soot emissions	0.94 (0.1, 4.0)	0.94 (0.1, 4.0)	[1]	Low
– from sulphur emissions	-7.4 (-19, -2.6)	-7.4 (-19, -2.6)	[1]	Low
Aerosol-cloud interactions				
– from sulphur emissions	No best estimates	No best estimates	–	Very low
– from soot emissions			–	
Net aviation (Non-CO_2 terms)	66.6 (21, 111)	114.8 (35, 194)	–	–
Net aviation (All terms)	100.9 (55, 145)	149.1 (70, 229)	–	–

Lee et.al. 2021



TU Delft Arvind Gangoli Rao, SAF Congress, 2024

The various aspects of SAF


SAF

Technologies

Industrialization

Sustainability

Societal Aspects

Policies

Certification

Economics

Operations

Thank you

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