SAF POLICY AND MARKET

Topsoe Catalysis Forum

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12 September 2023

SKYNRG IS A PIONEER AND LEADER IN SUSTAINABLE AVIATION FUEL

We are a SAF capacity developer

We supply SAF to airlines

We provide SAF solutions for corporate and individual travelers

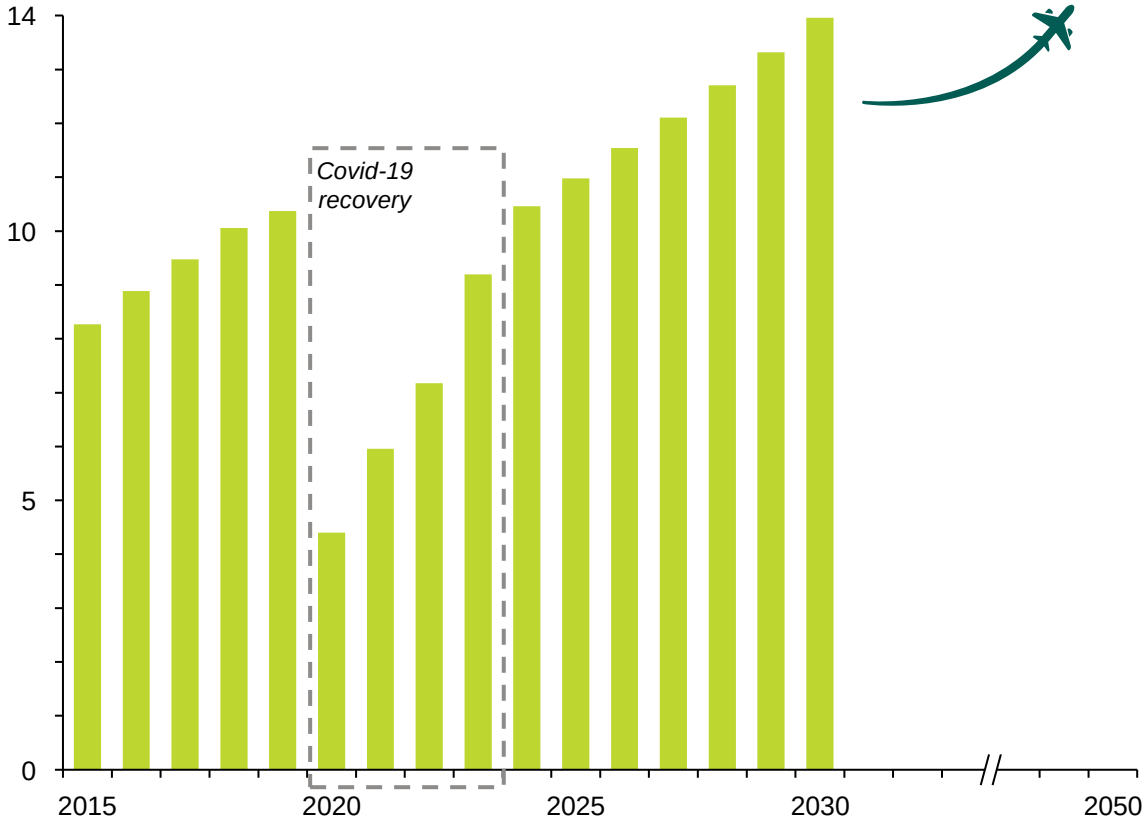
We provide advisory services on SAF

We do not compromise on sustainability

DECARBONISING AVIATION IS A MAJOR AND GROWING CHALLENGE

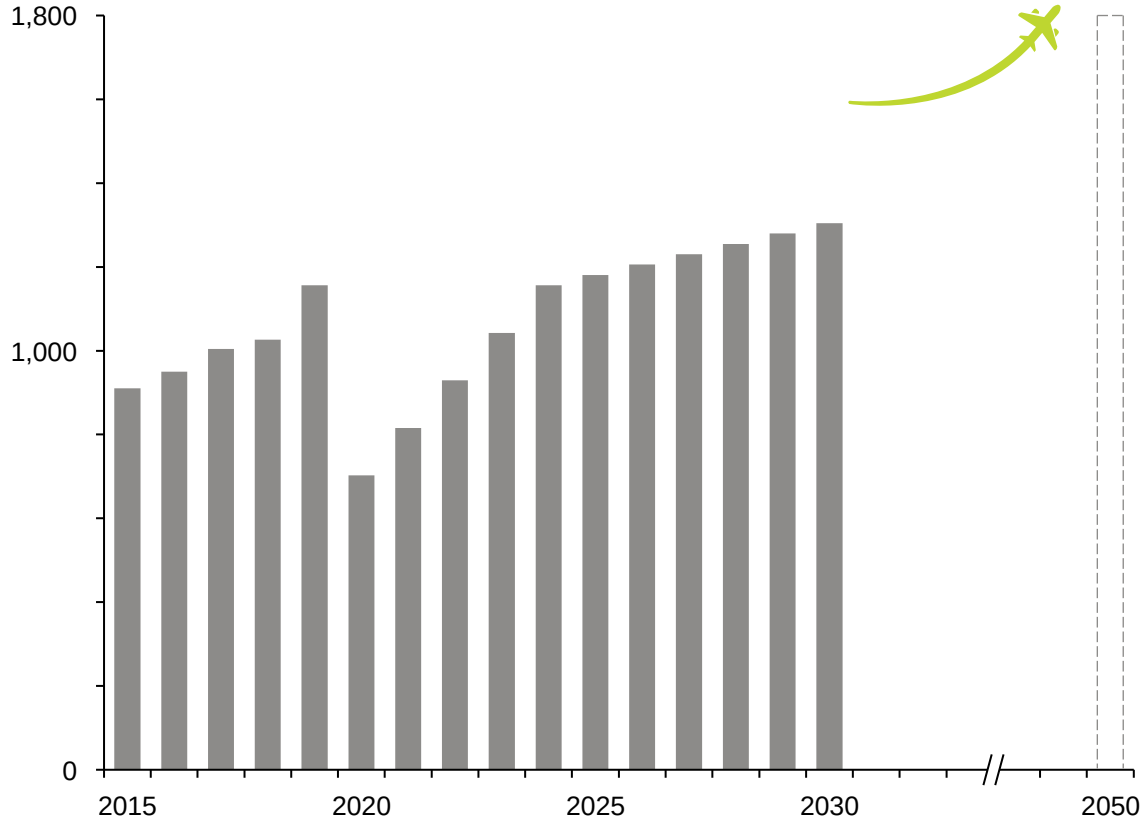
Aviation expected to continue to grow to ~14m ASK by 2030

Available Seat Kilometres (m)



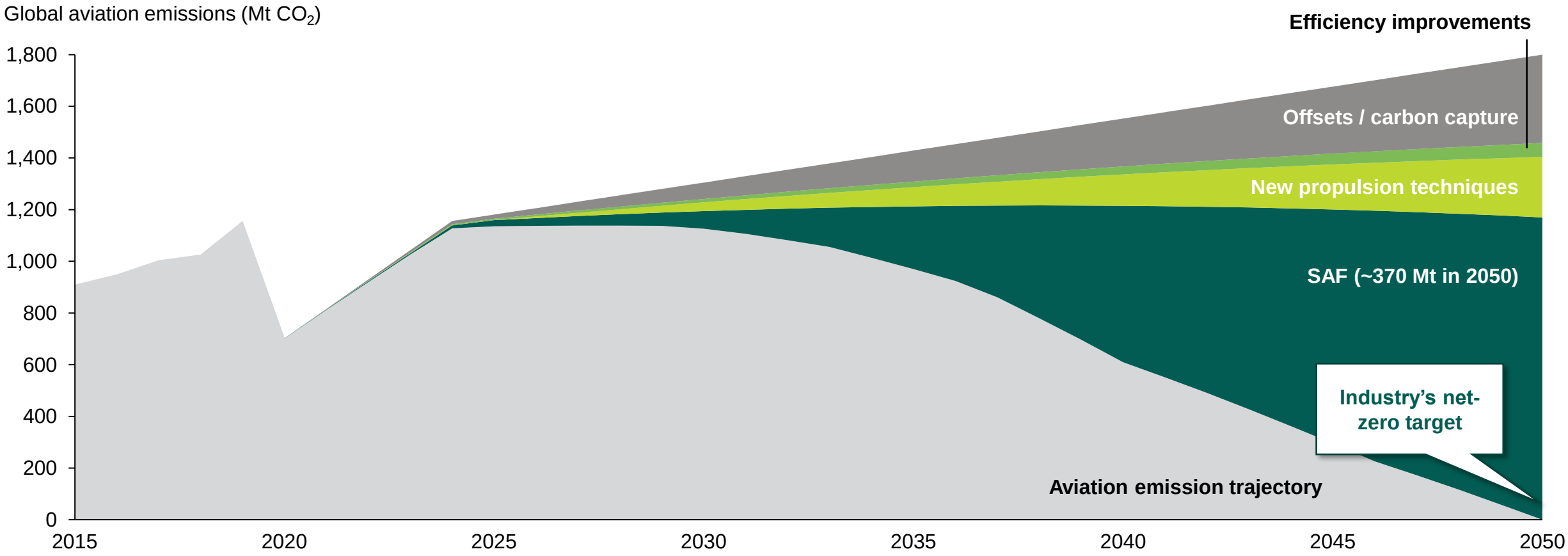
Without reduction efforts, emissions can grow to 1.8 Gt by ’50

Global aviation emissions (Mt CO2) – without reduction efforts



Source: Wall Street Research on Aerospace and Defence Data, IATA 2021, FCH JU & McKinsey Study (2020)

SAF IS CRUCIAL TO REACH NET-ZERO INDUSTRY TARGET BY 2050

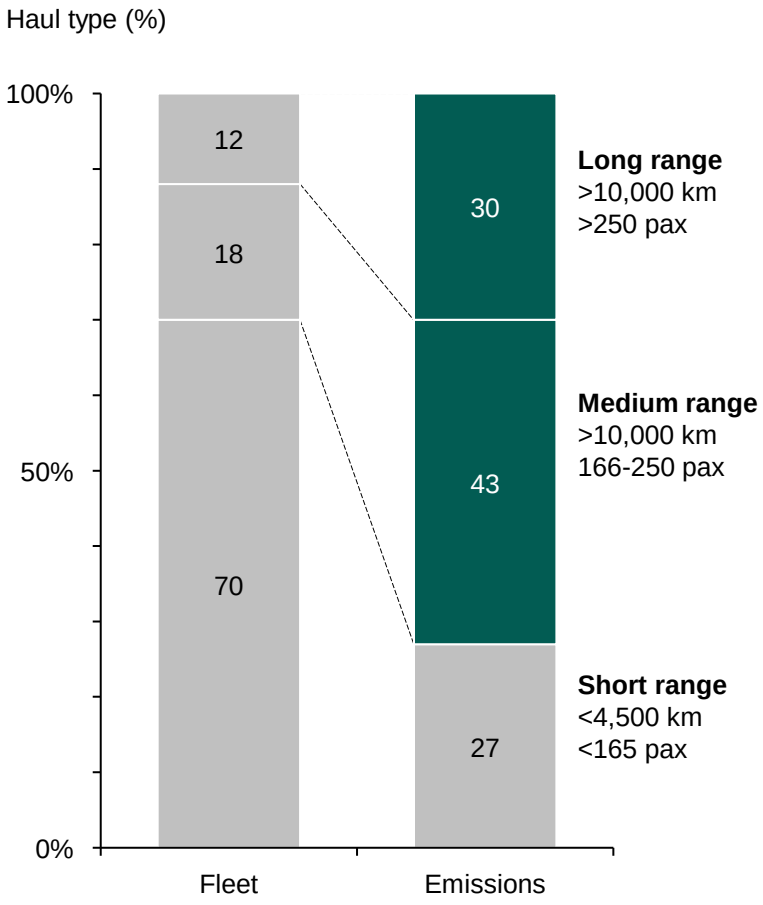


SAF market expected to grow from €0.2B today to €50B in 2030, to >€500B in 2050

Source: Wall Street Research on Aerospace and Defence Data, IATA 2021

SAF ONLY ALTERNATIVE FOR FOSSIL FUEL FOR ~75% OF EMISSIONS

Med/long haul drives ~75% of emissions



Alternatives are short-haul focused and less compatible with existing infrastructure

	New propulsion techniques			SAF
	H2 Combustion	Battery Electric	H2 fuel cell	
Description	• Modified gas-turbine engine driven by burning hydrogen	• Electricity from battery drives a propeller	• Hydrogen converted into electricity to drive a propeller	• Conventional jet engine fuelled by SAF
Medium/long haul applicability	• 4x less energy dense vs. kerosene	• >30x less dense • Propeller propulsion	• Less dense • Propeller propulsion	• Same energy density
Existing aircraft/ infrastructure compatibility	• Liquid hydrogen infrastructure • Modification to gas-turbine	• Fast charging or battery swap system • New propulsion system	• Liquid hydrogen infrastructure • New propulsion system	• No changes required

Source: FCH JU & McKinsey Study (2020).

SAF CAN BE PRODUCED FROM A VARIETY OF FEEDSTOCK AND PRODUCTION PATHWAYS

/ NON-EXHAUSTIVE

			Process description	Feedstock availability	Technology readiness
Oils and fats	**HEFA**	Hydro-processed Esters and Fatty Acids	Oils and fats react with hydrogen in the presence of a catalyst to produce SAF		
	Co-processing oils and fats		Co-processing oils and fats in existing crude oil refineries		
Solid biomass (residues, MSW)	**AtJ**	Alcohol-to-Jet	Feedstock is fermented to produce an alcohol (e.g., ethanol) and then converted to SAF		
	G+FT	Gasification and Fischer-Tropsch	Feedstock is decomposed into syngas and then converted via Fischer-Tropsch process to SAF		
Other	**PtL**	Power-to-Liquids | eSAF	CO2 and (green) hydrogen are combined to produce syngas and converted to SAF		

POLICIES IN EUROPE & NORTH AMERICA DRIVE SAF DEMAND & SUPPLY

RED II | ReFuelEU | UK JetZero

- **Mandates** | Share of SAF in jet fuel supply (6% in 2030, 70% in 2050)
- **Sub-mandates** | For e-SAF (35% in 2050)
- **GHG threshold** | ReFuelEU >65%
- **Feedstock** | Caps on oils and agricultural commodities

SAF Grand Challenge | IRA | RFS | LCFS

- **Aspirational goal** | 3.0 Bgal SAF in 2030 and 100% SAF share in 2050, supported by federal and state tax incentives
- **Sub-mandates** | Not in place
- **GHG threshold** | SAF Grand Challenge >50%
- **Feedstock** | Majority agricultural commodities

GLOBAL

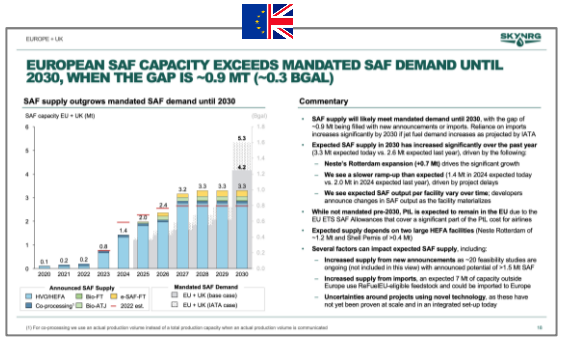
METHODOLOGY: OUR SAF MARKET OUTLOOK IS SPLIT INTO A 2030 AND 2050 FORECAST

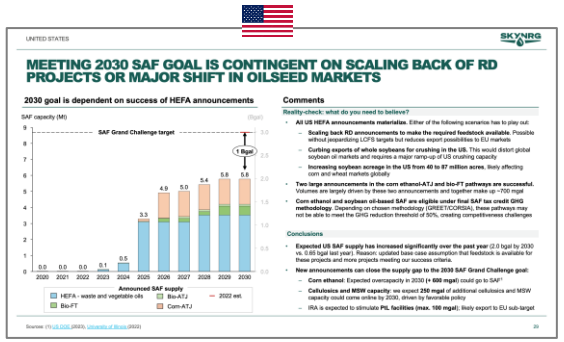
2030 | Bottom-up approach

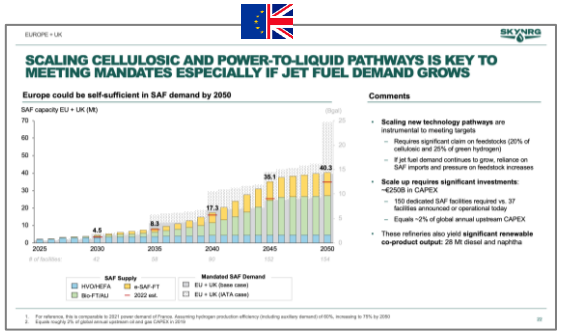
- **Methodology** | **Detailed bottom-up analysis** of renewable diesel and SAF facility announcements
  - Identified **announced and existing renewable fuel capacity**
  - Excluded facilities that are considered **unlikely to produce SAF**
    E.g., feasibility phase, biodiesel plants, unlikely to materialize
  - Estimated **realistic SAF output** for each facility
    Based on market intelligence and realistic SAF yields
- **New in 2023** | New announcements added and pulled feedstock analysis separate from supply analysis

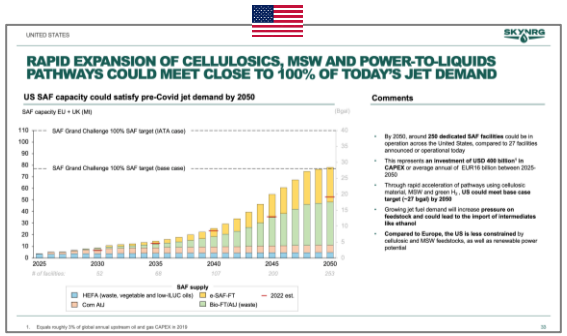
2050 | Modelled approach

- **Methodology** | S-curve forecasting model with feedstock constraints
  - S-curve growth model based on **corn ethanol deployment** in US post 2028
  - **Feedstock availability modelled separately** based on biomass studies (Billion Ton Report for US and S2BIOM for EU)
  - Feedstock constraints based on **assumptions on claim aviation**
- **New in 2023** | New modelling approach – S-curve replaces capacity growth model based on plant deployment rates





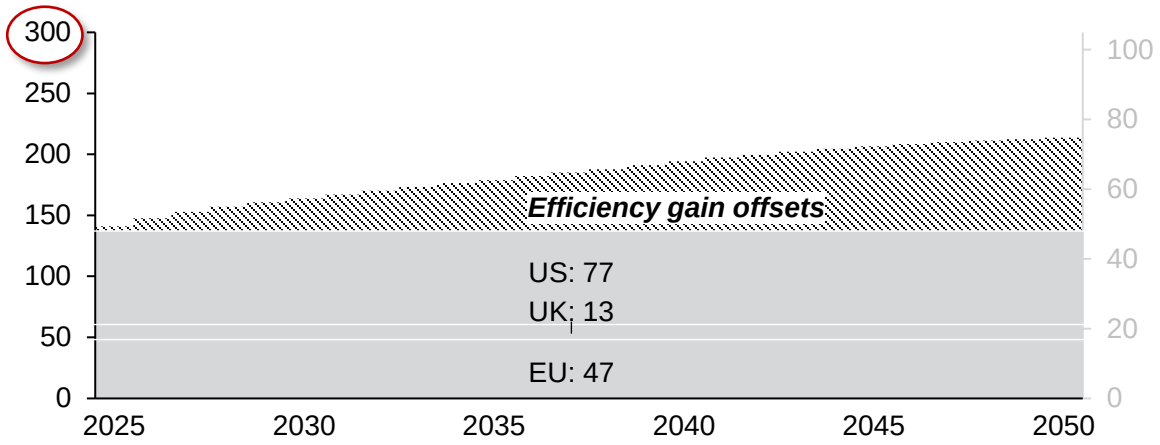




METHODOLOGY:
SAF DEMAND ANALYSIS IS BASED ON TWO SCENARIOS

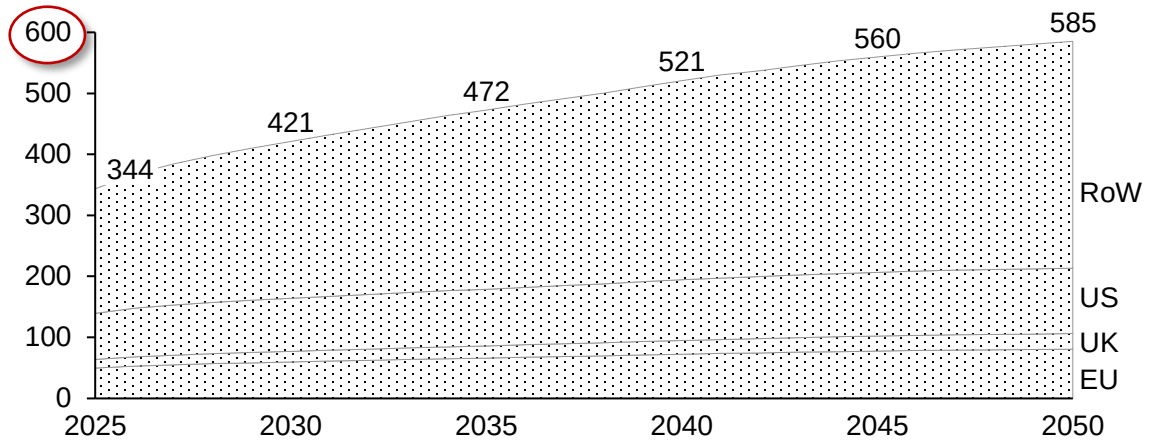
Base case: jet fuel demand growth offset by efficiency

Jet fuel consumption (Mt, markets in scope only: US, UK, EU) (Bgal)



IATA case: jet fuel demand increase with ~2.15% CAGR

Jet fuel consumption (Mt, global)



KEY ASSUMPTIONS

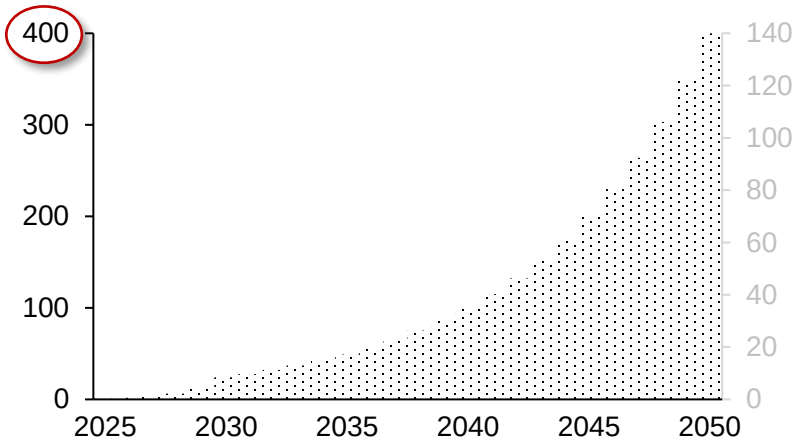
- Jet fuel demand has **returned to 2019 levels by 2025**[1]
- Jet fuel demand growth is **offset by aircraft efficiency gains** in specified regions

- **Similar jet fuel demand levels by 2025** for US (~76 Mt), UK (~14), EU (~50)
- **Global jet fuel demand growth of ~2.15% CAGR** (2025-2050), with EU (~1.9%) and US (~1.4%) below global CAGR and UK above (~2.4%)

Sources: (1) EIA (2019) for UK, Eurostat for EU, EIA (2022) for US | (2) IATA forecast (2023)

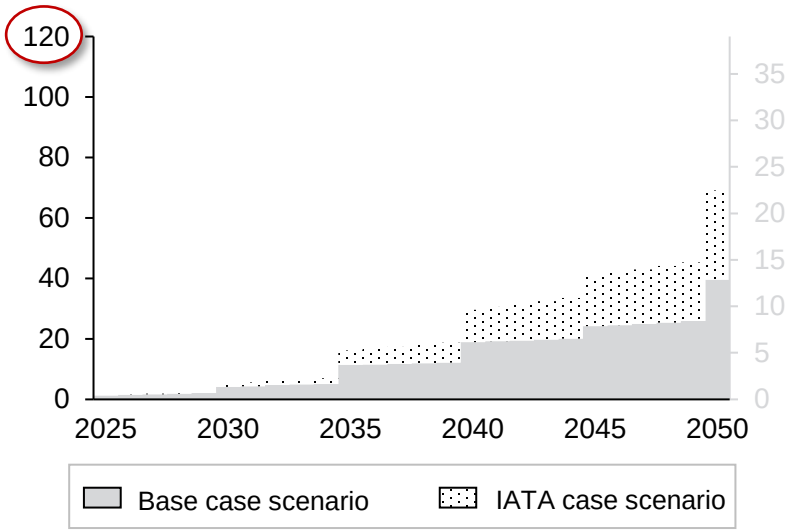
TOTAL GLOBAL SAF DEMAND ESTIMATED AT ~400 MT BY 2050, KICK-STARTED BY POLICIES IN EUROPE, UK AND US

Global



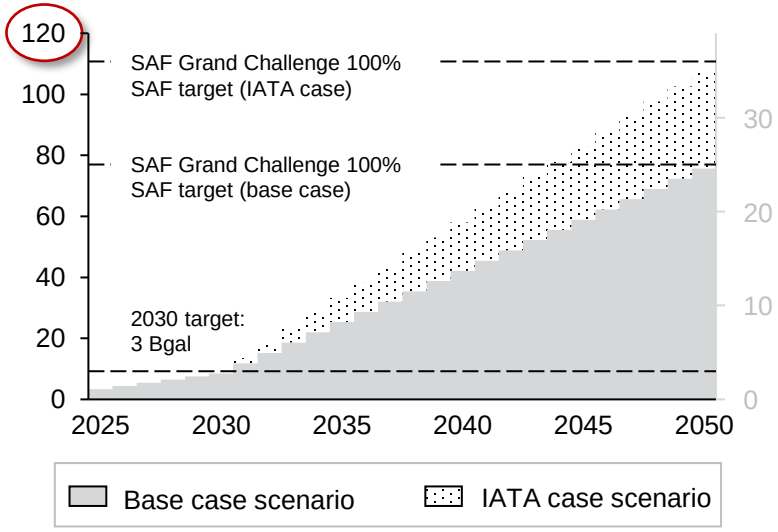
IATA's most recent roadmap to net-zero requires SAF to cover 62% of aviation's emission reduction[1]

Europe | UK



RefuelEU and UK blending mandate drive EU's SAF demand with a **stick approach** – enforcing mandates with penalties

United States



SAF Grand Challenge is an aspirational SAF production target, supported by the IRA with a **carrot approach** – incentivizing supply through financial incentives

FOCUS OF SAF MARKET OUTLOOK

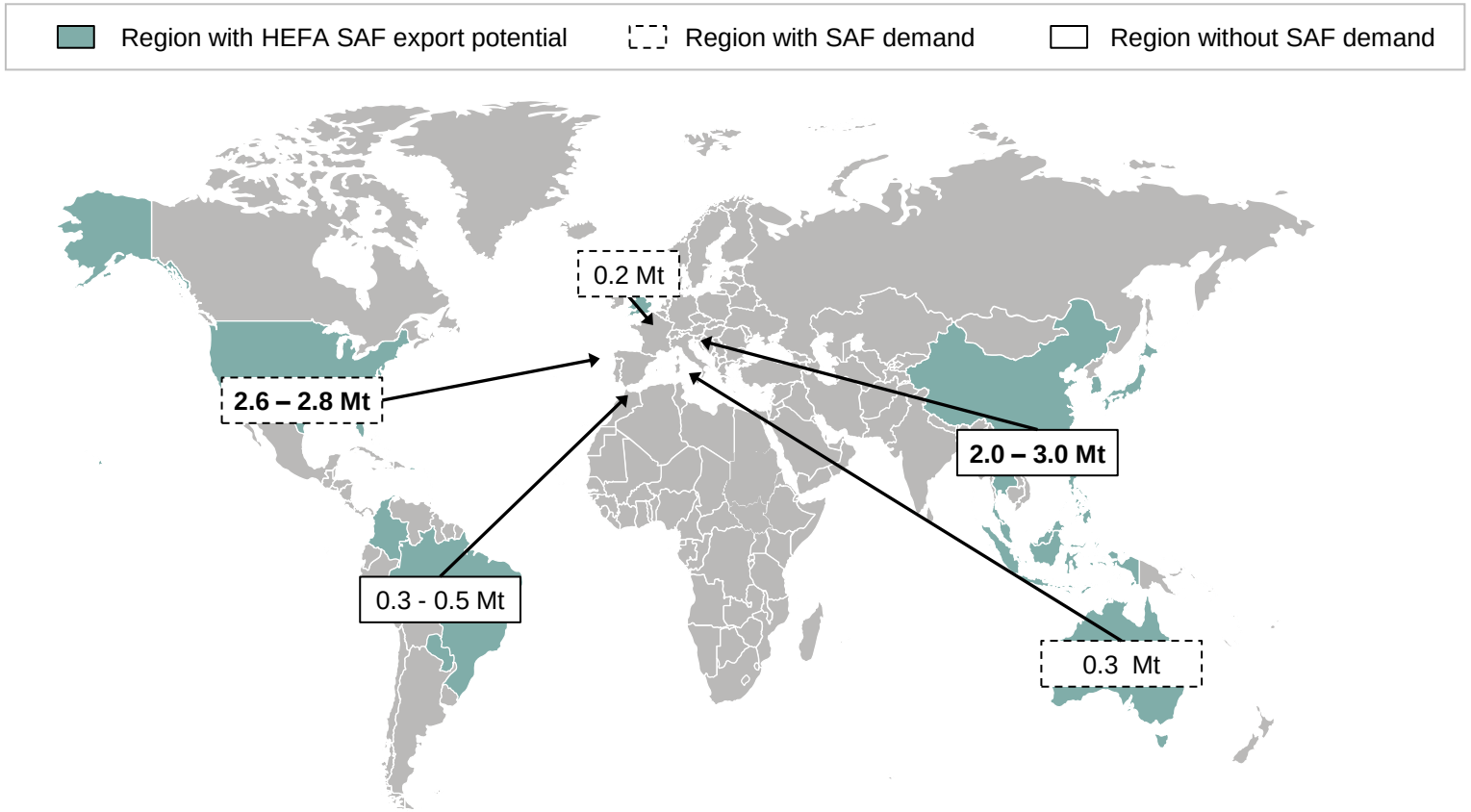
Sources: (1) IATA (2023) – applying linear interpolation between 5-year figures published by IATA

2030 | WE EXPECT WASTE OIL SAF TO FLOW TO THE EU IF JET FUEL DEMAND CONTINUES TO GROW

SAF will flow to market with highest incentives for specific SAF type

	Policy design attracts:
EU	• **Waste oil SAF** | UK intends a waste oil cap to avoid displacement from road • **e-SAF** | Possible import from US* • **Low carbon fuels** | Nuclear power-based fuels are eligible
UK	• **Advanced and MSW based SAF** (incl. agricultural) | Not specifically mandated in EU • **e-SAF** | Possible import from US, depending on final sub-targets UK
US	• **Agricultural commodity based SAF** | E.g., soybean oil

Waste oil SAF: US, China + SEA largest potential export markets



Notes: (*) Hydrogen Production Tax Credit may trigger some e-SAF production in the US but will likely flow to EU+UK to meet the sub mandates

2030 | WE EXPECT THE SAF MARKET TO REMAIN UNDERSUPPLIED, AS VOLUNTARY DEMAND WILL PROVIDE ADDITIONAL MARKET PRESSURE

Airlines are increasingly committing to SAF targets

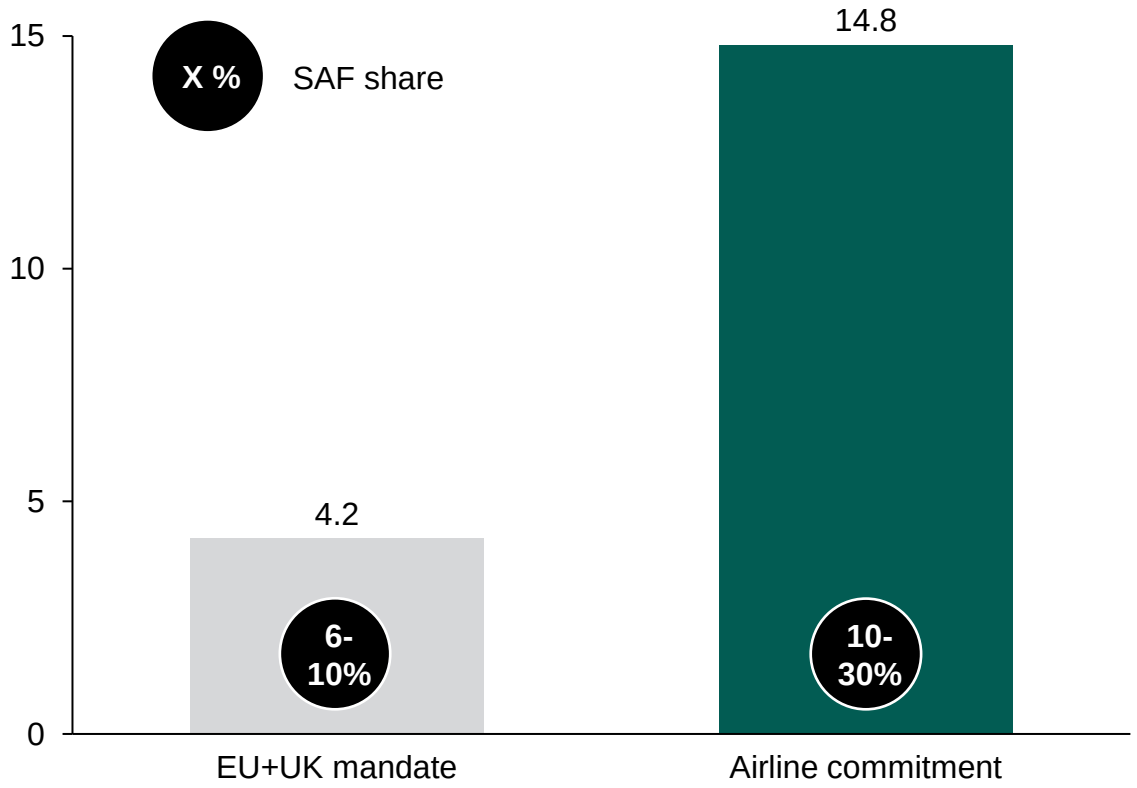
Airlines with SAF commitments (non-exhaustive)

DHL, KLM, United Airlines, Southwest, Lufthansa, Singapore Airlines, Alaska, Air Canada, American Airlines, Ryanair, Delta, jetBlue, Qantas, Cathay Pacific

SAF commitments exceed mandated SAF share EU/UK

AIRLINE EXAMPLES | NON-EXHAUSTIVE

Voluntary SAF demand (2030, Mt)



Sources: SkyNRG analysis of top 20 airlines per region (based on RPK), supplemented with airlines leading on SAF | Note (1) Part of airline commitments will likely be used to meet EU/UK mandates

EUROPE (EU + UK)

REFUELEU AND UK BLENDING MANDATES DRIVE DEMAND UP TO 2050

ReFuelEU mandate: approved to start in 2023

- **Mandated share of SAF** in the jet fuel supply to European airports
- **Provisional deal reached** this year
- **Start in 2025** with 2%, gradually increasing to **70% SAF share by 2050**
- **Sub-target for e-SAF** in place, including nuclear-based Power-to-Liquid

UK mandate: expected to be announced in Q3 2023

- **Mandated share of SAF** in the jet fuel supplied to UK airports
- **Currently under discussion**: final mandate expected Q3 2023
- **2030 mandated share announced** (10%), other years under discussion
- **Sub-target for e-SAF** in place

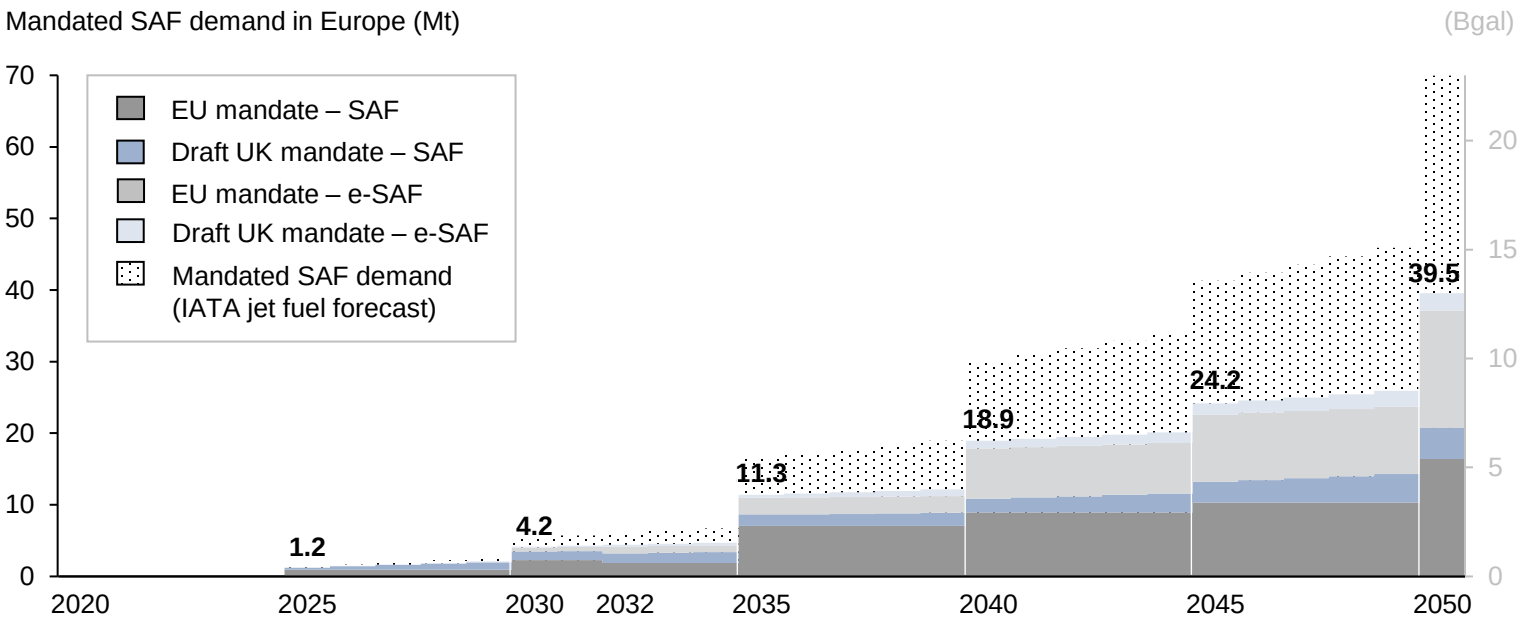
TARGETS | Minimum SAF share

	ReFuelEU		UK mandate	
	Total	**eSAF**	**Total[1]**	**eSAF[2]**
2025	2%		2%	0.05%
2030	6%	1.2%	10%	1%
2032	6%	2.0%		
2035	20%	5%	15%	3%
2040	34%	10%	22%	8%
2045	42%	15%	33%	12%
2050	70%	35%	50%	18%

Notes: (1) Assuming the “medium” scenario until 2040 and follows the trend to reach 50% SAF share by 2050 | (2) Assuming “very high” PtL scenario until 2040

SAF DEMAND EXPECTED TO BE >4.2 MT BY 2030 AND >39.5 MT BY 2050

SAF demand ramping up quickly post 2035 to at least 39.5 Mt in 2050



TARGETS | Minimum SAF share

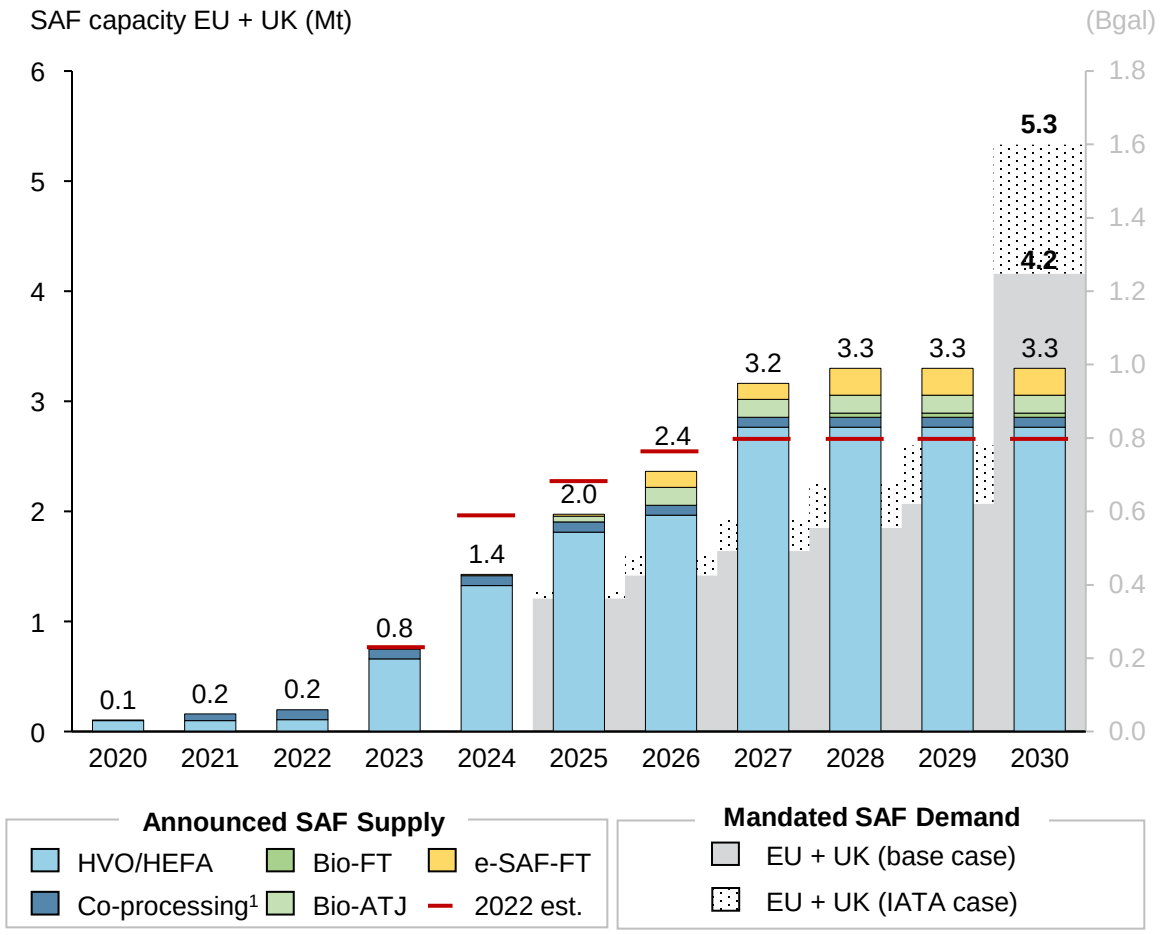
Total	2%	6%	6%	20%	34%	42%	70%
e-SAF	-	1.2%	2%	5%	10%	15%	35%
Total	2.%	10%		15%	22%	33%	50%
e-SAF	0.05%	1%		3%	8%	12%	18%

Commentary

- **Jet fuel scenario has major impact on SAF demand**, especially towards 2050
  - IATA forecasts >75 Mt jet fuel demand by ’30 and >100 Mt by ’50 (vs. ~47 Mt base case)
  - Meeting 2030 targets under IATA forecast requires an additional 1.1 Mt SAF
  - In 2050, this increases to + 30Mt SAF
- **Biofuels to provide majority of SAF in 2040s**
  - Recycled carbon fuels may push out some biofuels
  - Absence of advanced biofuels target may lead to shift of Annex IX-B feedstock from road to aviation and pressure on import
- **eSAF mandate to drive development** of these newer “synthetic” fuels
  - “Low carbon aviation fuels” eligible as eSAF, covering nuclear power based SAF
  - New definition could take away market share from eSAF made from green hydrogen

EUROPEAN SAF CAPACITY EXCEEDS MANDATED SAF DEMAND UNTIL 2030, WHEN THE GAP IS ~0.9 MT (~0.3 BGAL)

SAF capacity outgrows mandated SAF demand until 2030



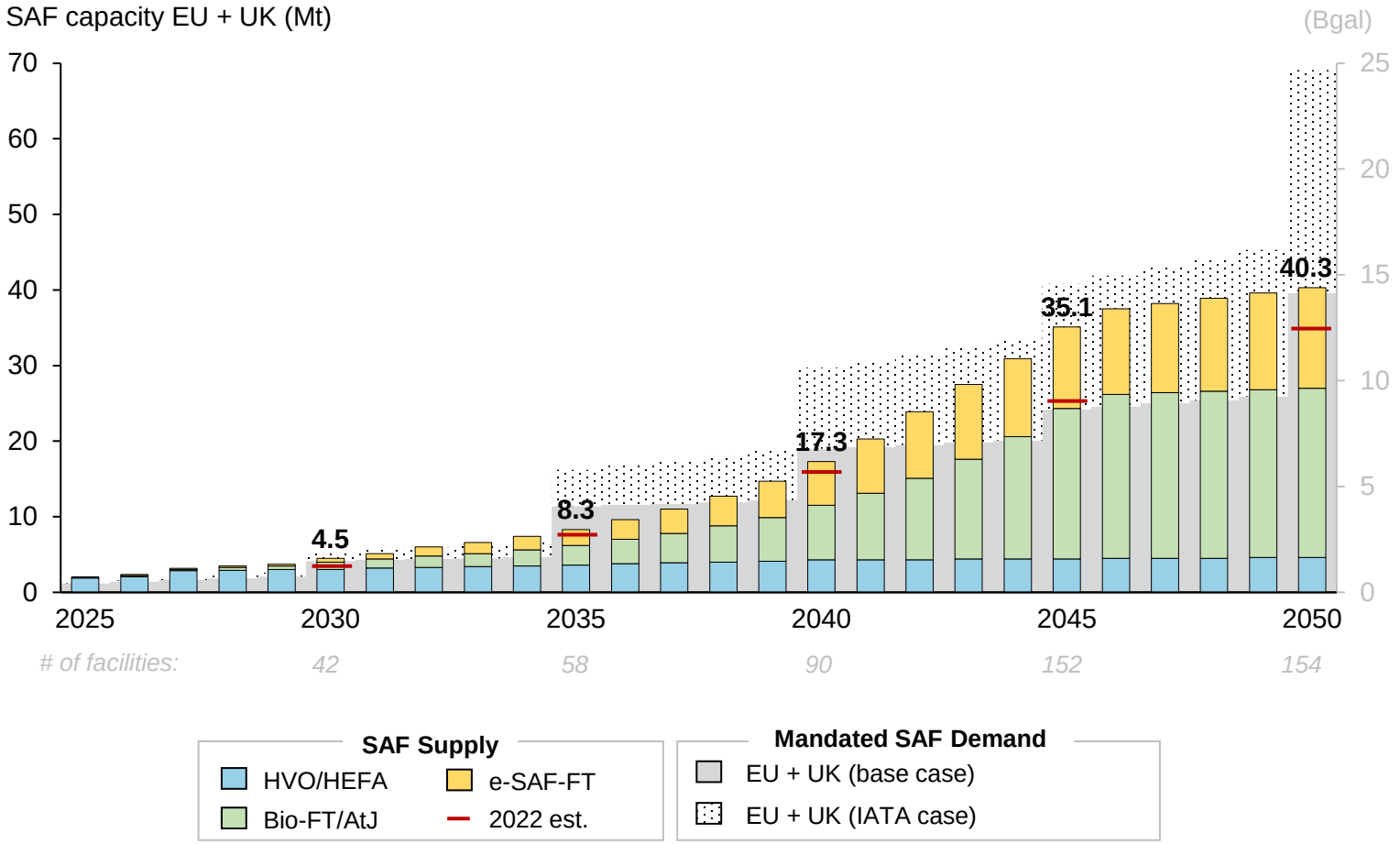
Commentary

- **SAF capacity will likely meet mandated demand until 2030**, with the gap of ~0.9 Mt being filled with new announcements or imports. Reliance on imports increases significantly by 2030 if jet fuel demand increases as projected by IATA
- **Expected SAF capacity in 2030 has increased significantly over the past year** (3.3 Mt expected today vs. 2.6 Mt expected last year), driven by the following:
  - **Neste's Rotterdam expansion (+0.7 Mt)** drives the significant growth
  - **We see a slower ramp-up than expected** (1.4 Mt in 2024 expected today vs. 2.0 Mt in 2024 expected last year), driven by project delays
  - **We see expected SAF output per facility vary over time**; developers announce changes in SAF output as the facility materializes
- **While not mandated pre-2030, PtL is expected to remain in the EU** due to the EU ETS SAF Allowances that cover a significant part of the PtL cost for airlines
- **Expected capacity depends on two large HEFA facilities** (Neste Rotterdam of ~1.2 Mt and Shell Pernis of >0.4 Mt)
- **Several factors can impact expected SAF capacity**, including:
  - **New announcements** as ~20 feasibility studies are ongoing (not included in this view) with announced potential of >1.5 Mt SAF
  - **Imports**, an expected 7 Mt of capacity outside Europe use ReFuelEU-eligible feedstock and could be imported to Europe
  - **Uncertainties around projects using novel technology**, as these have not yet been proven at scale and in an integrated set-up today

(1) For co-processing we use an actual production volume instead of a total production capacity when an actual production volume is communicated

SCALING CELLULOSIC AND POWER-TO-LIQUID PATHWAYS IS KEY TO MEETING MANDATES ESPECIALLY IF JET FUEL DEMAND GROWS

Europe could be self-sufficient in SAF demand by 2050



Comments

- **Scaling new technology pathways** are instrumental to meeting targets
  - Requires significant claim on feedstocks (20% of cellulosic and 25% of green hydrogen)
  - If jet fuel demand continues to grow, reliance on SAF imports and pressure on feedstock increases
- **Scale up requires significant investments**: ~€250B in CAPEX
  - 150 dedicated SAF facilities required vs. 37 facilities announced or operational today
  - Equals ~2% of global annual upstream CAPEX
- These refineries also yield **significant renewable co-product output:** 28 Mt diesel and naphtha

1. For reference, this is comparable to 2021 power demand of France. Assuming hydrogen production efficiency (including auxiliary demand) of 60%, increasing to 75% by 2050
2. Equals roughly 2% of global annual upstream oil and gas CAPEX in 2019

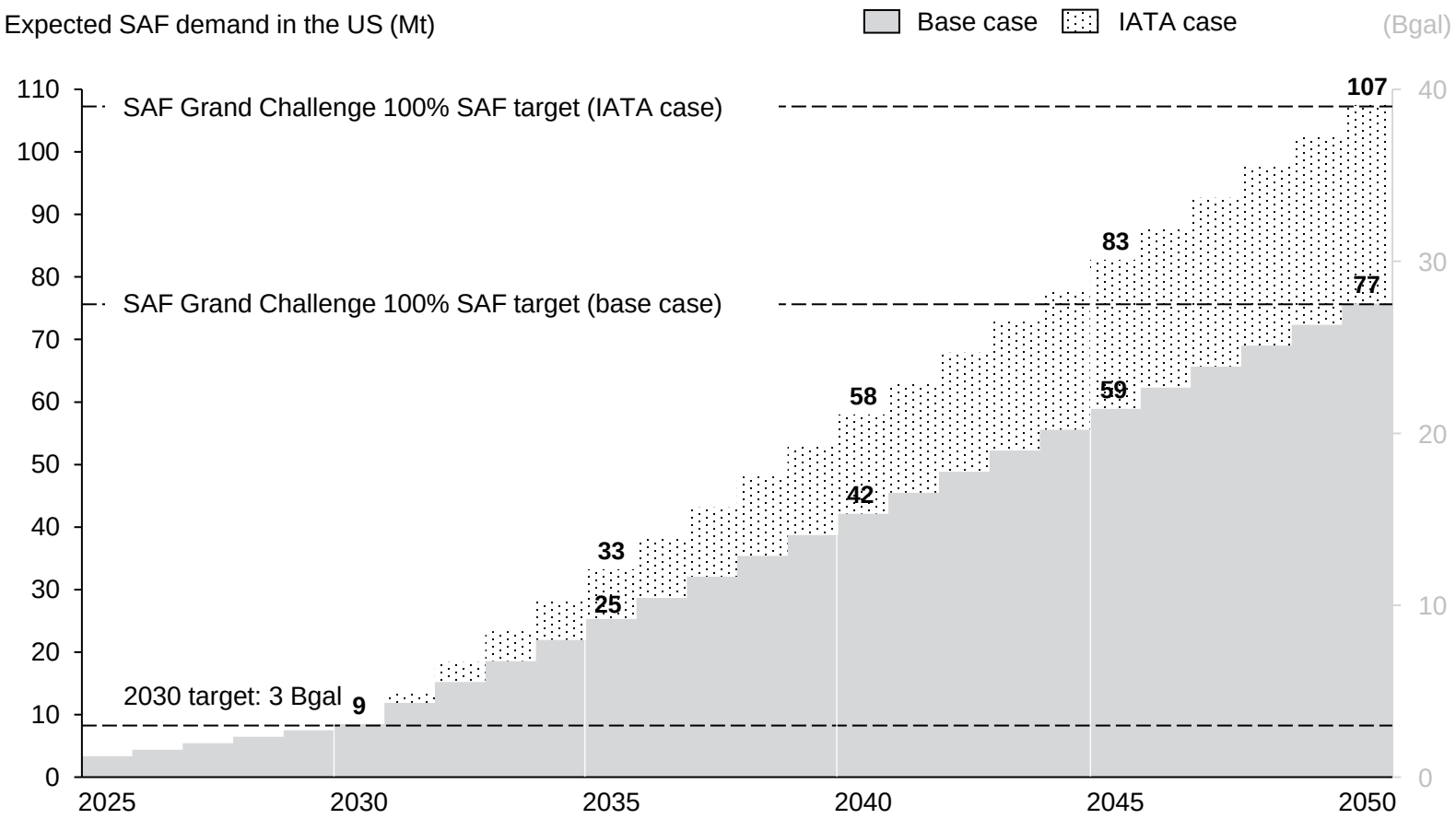
UNITED STATES

US SAF TARGETS ARE SUPPORTED WITH FINANCIAL INCENTIVES AT FEDERAL AND STATE LEVEL

Federal			State	
SAF Grand Challenge	**IRA | Inflation Reduction Act**	**RFS | Renewable Fuel Standard**	**LCFS | Low Carbon Fuel Standard**	**State level tax credits (IL, WA)**
Domestic **SAF production goals** and a coordinated federal approach to achieve these	Major tax and spending package, including **tax credits** to incentivize domestic SAF production	Fuel supplier **obligation to sell certain volume of renewable fuels**, with a tradeable **credit system**	Mandate on **maximum carbon intensity of fuel** for fuel suppliers, with a tradeable **credit system**	State tax incentives: SAF **consumption credit** for airlines (IL) or **production credit** (WA)
Type: Regulatory	Financial	Regulatory		Financial
Enabling: Supply				Supply / demand

SAF GRAND CHALLENGE COULD MEAN A SAF DEMAND OF 8.7 MT (3 BGAL) BY 2030 AND 77 MT (27 BGAL) BY 2050

US SAF demand expected to reach 77 Mt by 2050



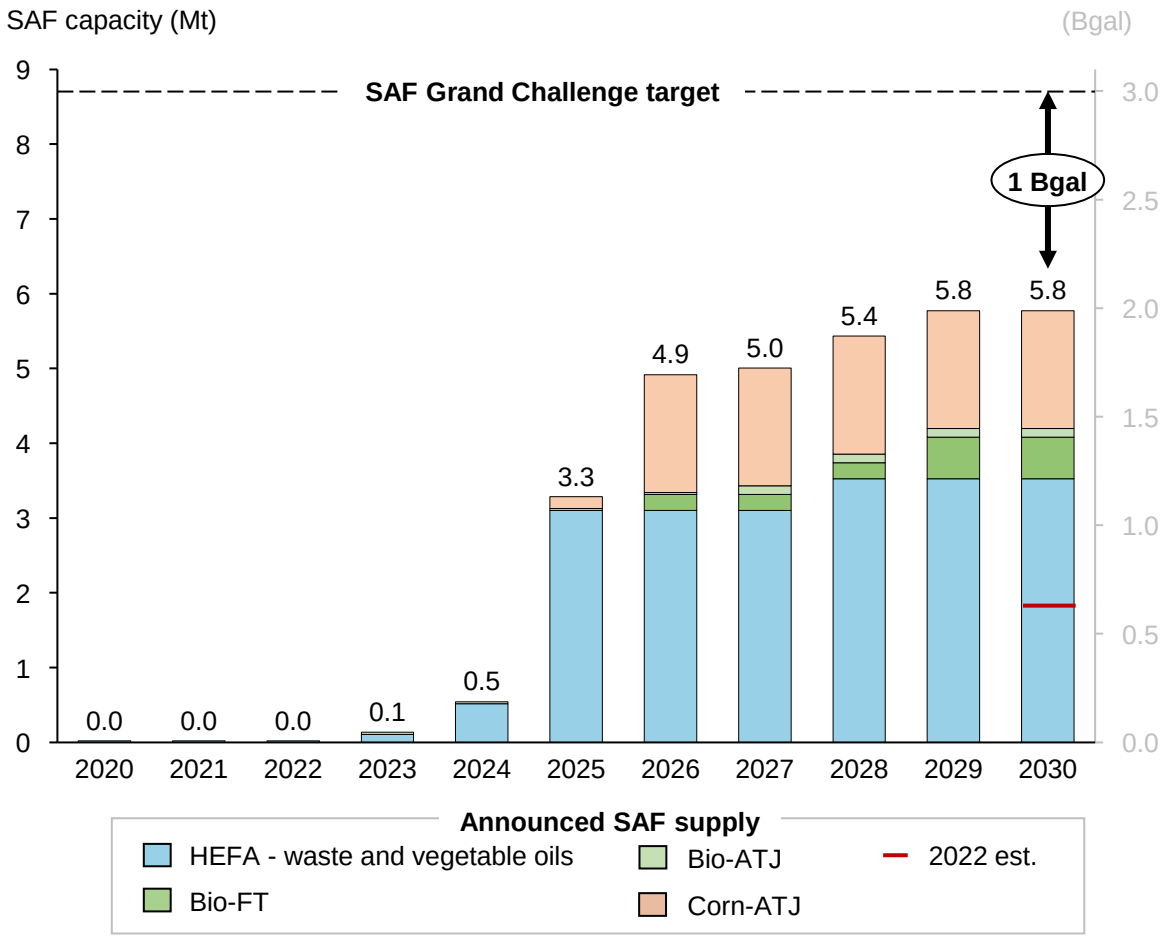
Comments

- Under its Sustainable Aviation Fuel Grand Challenge, the US is planning to increase production of **SAF to 8.7 Mt (3 bgal) by 2030**
- Putting this into perspective, this corresponds to:
  - **~10% of US' jet fuel consumption**
  - Nearly **2x the expected volume in Europe**
- By 2050 the US 100% target would require for
  - **Constant scenario: 77 Mt[1] (27.2 bgal)**
  - **IATA growth scenario: 107 Mt (37.9 bgal)**
- **Being time-bound**, **most of the tax incentives** supporting this challenge are considered **insufficient** to de-risk and drive investment into the technology-feedstock combinations needed **to reach 2050 goals**

1. US jet fuel consumption 2022 (Source: EIA, 2022)

MEETING 2030 SAF GOAL IS CONTINGENT ON SCALING BACK OF RD PROJECTS OR MAJOR SHIFT IN OILSEED MARKETS

2030 goal is dependent on success of HEFA announcements



Comments

Reality-check: what do you need to believe?

- **All US HEFA announcements materialize.** Either of the following scenarios has to play out:
  - **Scaling back RD announcements to make the required feedstock available**. Possible without jeopardizing LCFS targets but reduces export possibilities to EU markets
  - **Curbing exports of whole soybeans for crushing in the US.** This would distort global soybean oil markets and requires a major ramp-up of US crushing capacity
  - **Increasing soybean acreage in the US from 40 to 87 million acres**, likely affecting corn and wheat markets globally
- **Two large announcements in the corn ethanol-ATJ and bio-FT pathways are successful.** Volumes are largely driven by these two announcements and together make up ~700 mgal
- **Corn ethanol and soybean oil-based SAF are eligible under final SAF tax credit GHG methodology**. Depending on chosen methodology (GREET/CORSIA), these pathways may not be able to meet the GHG reduction threshold of 50%, creating competitiveness challenges

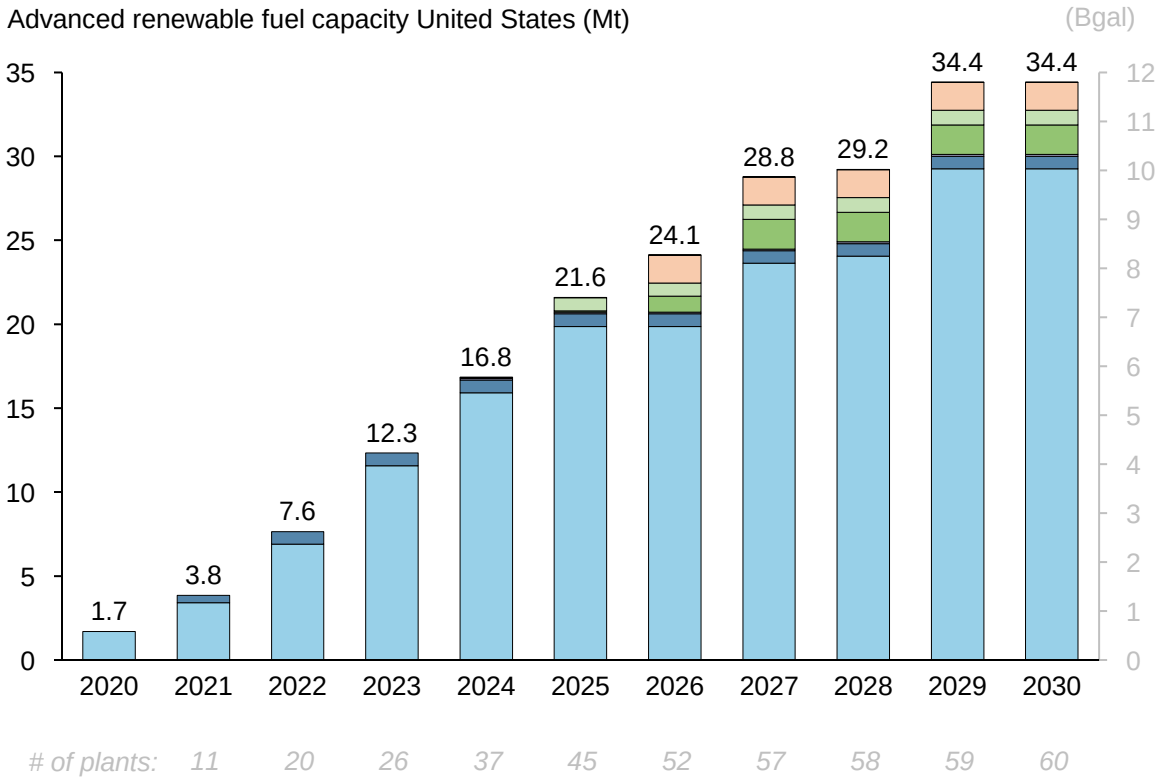
Conclusions

- **Expected US SAF supply has increased significantly over the past year** (2.0 bgal by 2030 vs. 0.65 bgal last year). Reason: updated base case assumption that feedstock is available for these projects and more projects meeting our success criteria.
- **New announcements can close the supply gap to the 2030 SAF Grand Challenge goal:**
  - **Corn ethanol**: Expected overcapacity in 2030 **(+ 600 mgal**) could go to SAF[1]
  - **Cellulosics and MSW capacity**: we expect **250 mgal** of additional cellulosics and MSW capacity could come online by 2030, driven by favorable policy
  - IRA is expected to stimulate **PtL facilities (max. 100 mgal**); likely export to EU sub-target

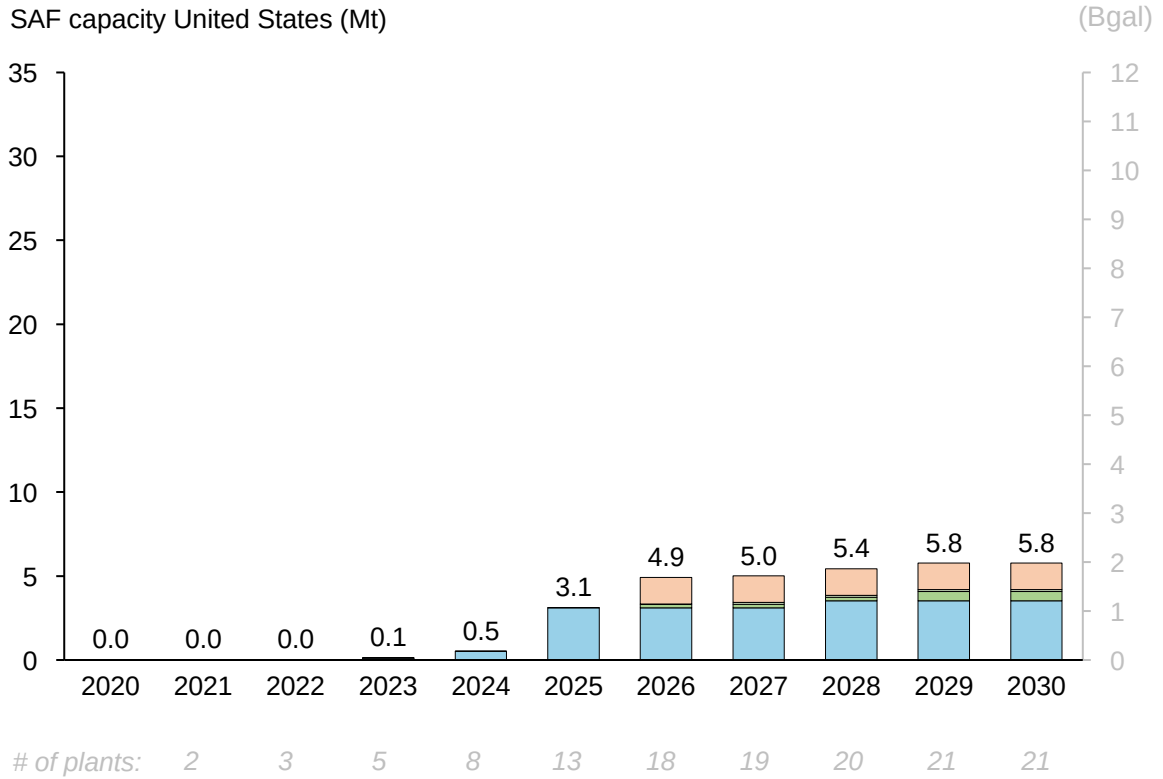
Sources: (1) US DOE (2023), University of Illinois (2022)

UNITED STATES IS MAINLY FOCUSED ON RENEWABLE DIESEL, WITH 5.8 MT OUT OF ~34.4 MT RENEWABLE FUEL EXPECTED TO BE SAF

HEFA facilities drive US renewable fuel growth to 2030



SAF capacity increases to 5.8, step-change in 2025

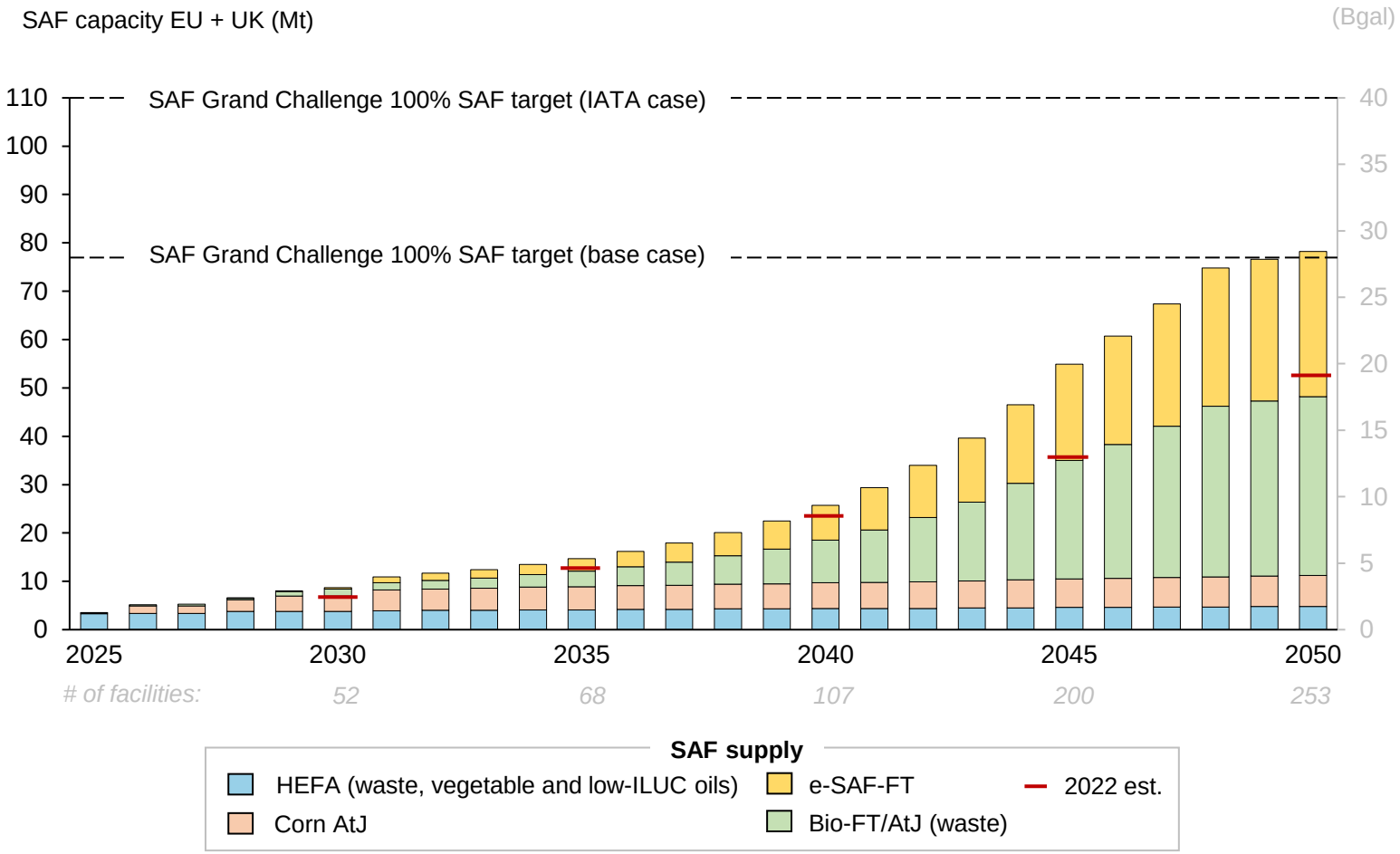


Technologies

HVO/HEFA | Co-processing | CHJ | Bio-FT | Bio-ATJ | Corn-AtJ | e-SAF-FT

RAPID EXPANSION OF CELLULOSICS, MSW AND POWER-TO-LIQUIDS PATHWAYS COULD MEET CLOSE TO 100% OF TODAY'S JET DEMAND

US SAF capacity could satisfy pre-Covid jet demand by 2050



Comments

- By 2050, around **250 dedicated SAF facilities** could be in operation across the United States, compared to 27 facilities announced or operational today
- This represents **an investment of USD 400 billion[1] in CAPEX** or average annual of EUR16 billion between 2025-2050
- Through rapid acceleration of pathways using cellulosic material, MSW and green H_2 , **US could meet base case target (~27 bgal) by 2050**
- Growing jet fuel demand will increase **pressure on feedstock and could lead to the import of intermediates like ethanol**
- **Compared to Europe, the US is less constrained** by cellulosic and MSW feedstocks, as well as renewable power potential

1. Equals roughly 3% of global annual upstream oil and gas CAPEX in 2019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