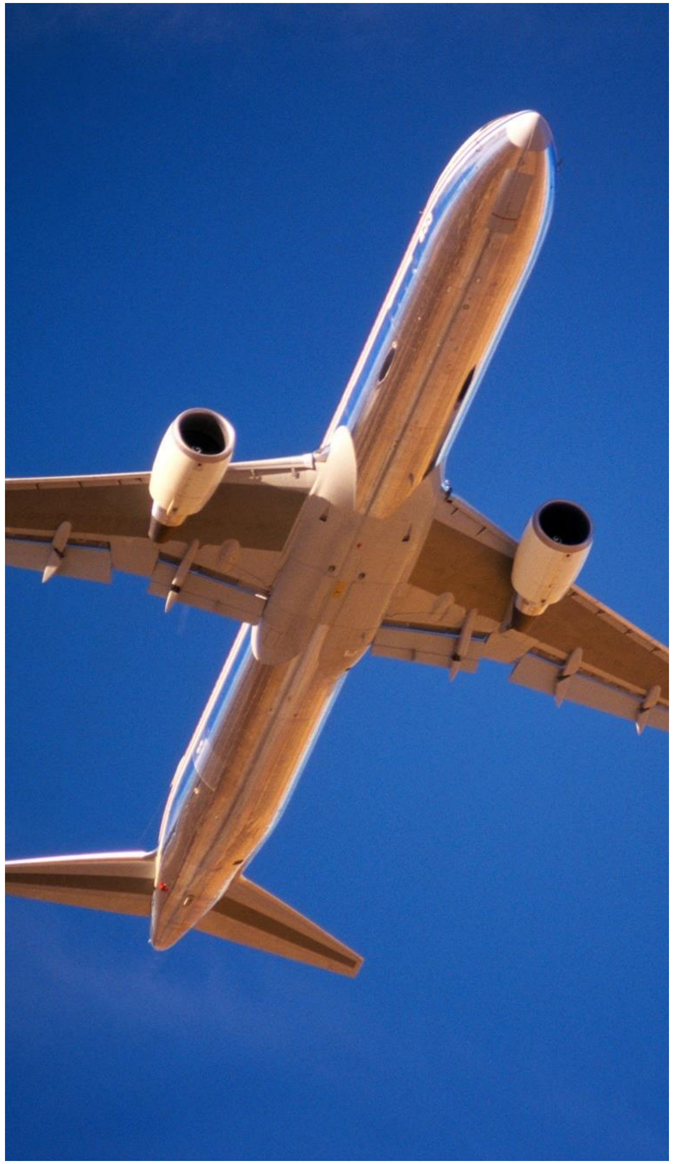
THE POTENTIAL OF LIGNOCELLULOSIC BIOMASS IN DECARBONIZING THE AVIATION INDUSTRY

Dusita de Hoop – Future Fuels

8th February 2024



WE ARE SKYNRG

We are a SAF capacity developer

We supply SAF to airlines

We provide SAF solutions for corporate and individual travelers

Sustainability is at the core of what we do

SKYNRG HAS BUILT A LEADING POSITION IN THE SAF INDUSTRY, WITH 10+ YEARS EXPERIENCE

2009
SkyNRG established, supplying the first commercial SAF flight

2011
Supplied SAF on every continent

2013
First SAF producer to obtain RSB certification

2014
Set up first corporate program with KLM

2016
Established long-term continuous supply chain at LAX

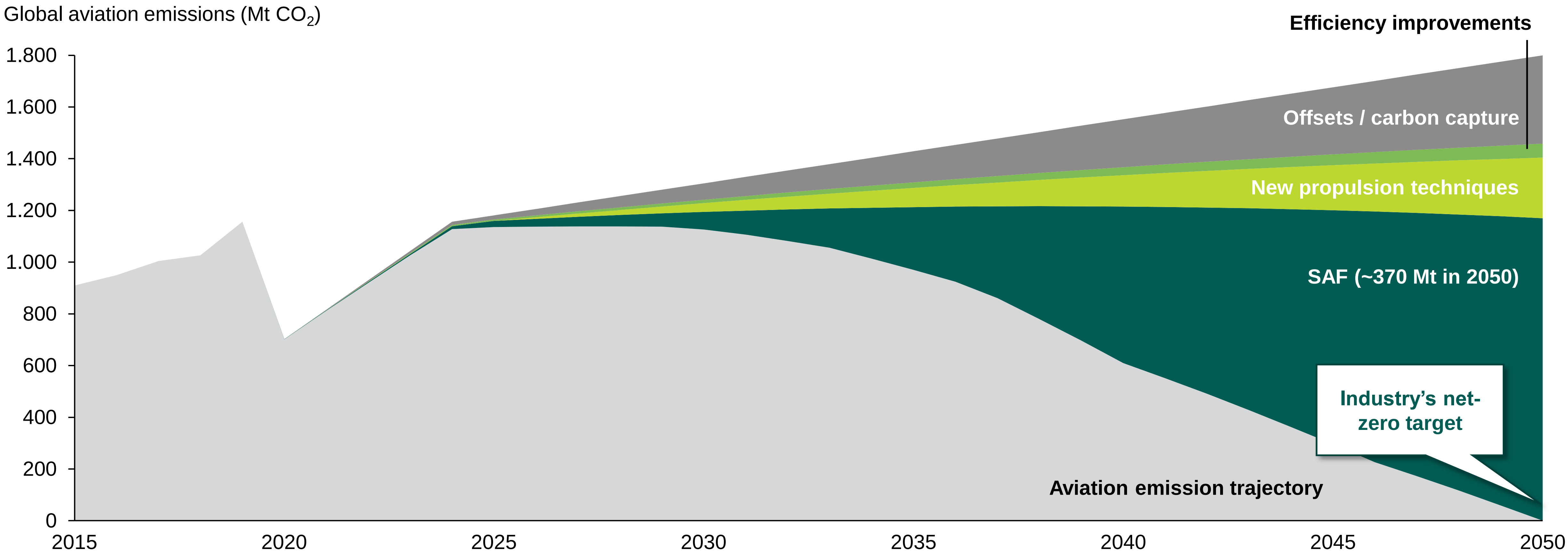
2019
Announced first European dedicated SAF facility

2020
Launched new SAF capacity projects in the US and EU

2021
Signed strategic global partnership with Boeing

2023
Raised investments with Macquarie Capital

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

THE SOLUTION

Sustainable aviation fuel – SAF – made from renewable resources **is the most effective way to reduce emissions** in the foreseeable future.

SAF ticks all the relevant boxes

SAF meets all performance and safety requirements and does not require infrastructure and aircraft adaptations

Proven at commercial scale
600,000+ flights and counting

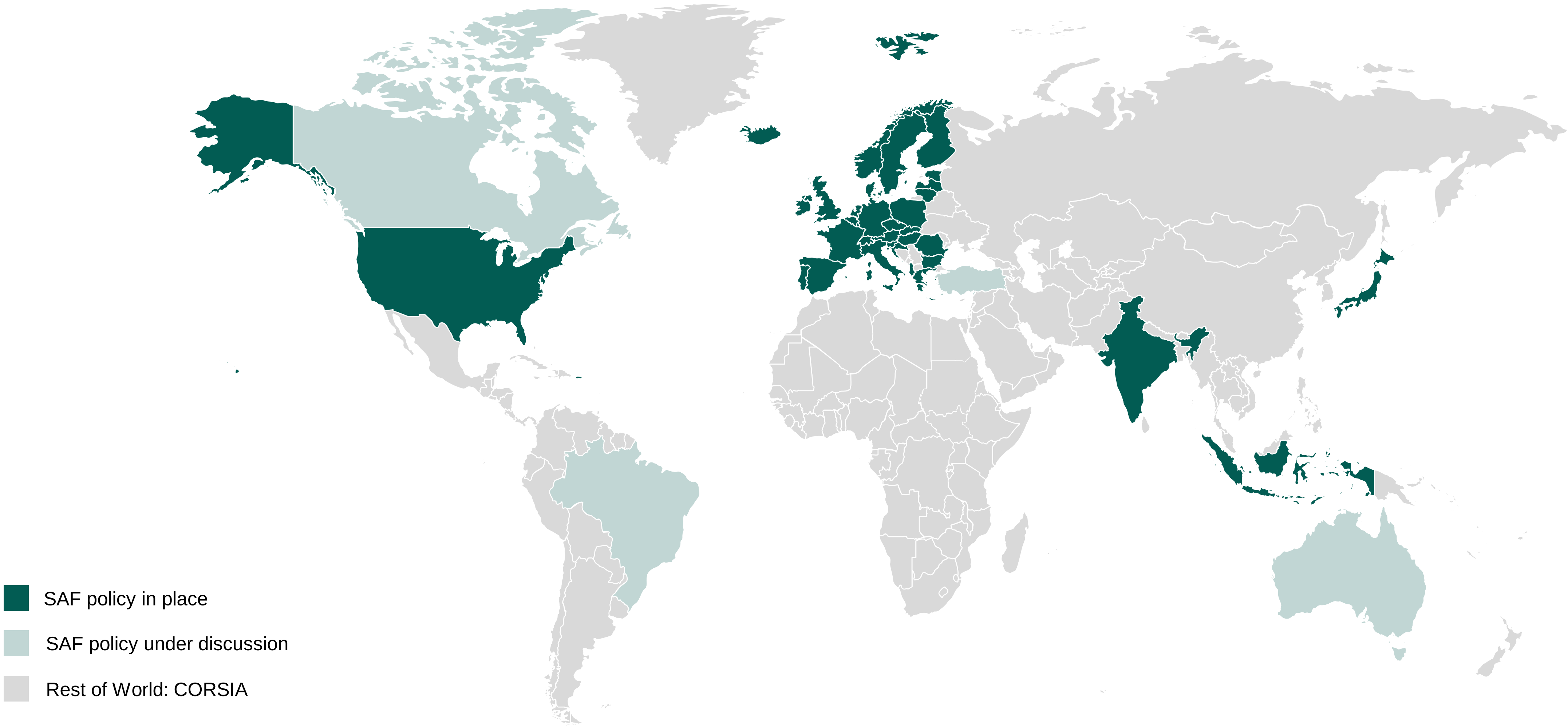
Various production pathways
ready for commercial deployment

SAF can **reduce life-cycle CO2 emissions by up to 95%**, depending on feedstock and production pathway

SAF CAN BE PRODUCED FROM THREE TYPES OF FEEDSTOCK THROUGH A VARIETY OF PRODUCTION PATHWAYS

Feedstock	Pathway	Description	Feedstock availability	Technology readiness
Oils and fats	**HEFA**	Hydro-processed Esters and Fatty Acids		
	CHJ	Catalytic Hydrothermolysis Jet Fuel		
	Co-processing Oils and Fats			
	HC-HEFA	Hydrocarbon-Hydroprocessed Esthers and Fatty Acids		
Biomass and MSW	**SIP**	Synthesized Iso-Paraffins		
	AtJ	Alcohol-to-Jet		
	MtJ	Methanol-to-Jet		
	FT	Fischer-Tropsch		
	Thermal Depolymerization (Pyrolysis and Hydrothermal Liquefaction)			
Other	**PtL**	Power-to-Liquids		

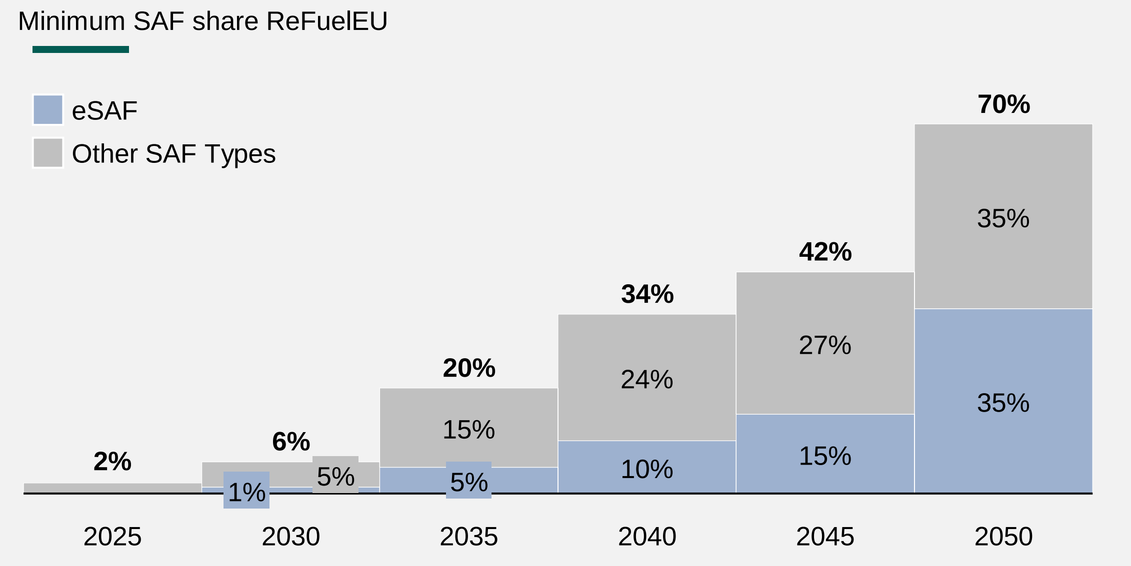
REGULATIONS ARE DRIVING SAF DEMAND AND SUPPLY



THE POTENTIAL OF LIGNOCELLULOSIC SAF IN DECARBONIZATION IS GOVERNED BY THE REFUEL EU AVIATION MANDATE

ReFuelEU mandate will kick in in 2025

- **Mandated share of SAF** in the jet fuel supply to European airports
- **Significant penalties** in place for non-compliance
- **Sub-target for e-SAF** in place



Strict sustainability and feedstock requirements

- **Excluded feedstocks:**
  Food, feed and intermediate crops, soy or palm derivatives
- **Accepted feedstocks:**
  - **Advanced biofuels**: Part A Annex IX (advanced technologies)
  - **Other biofuels**: Part B Annex IX (mature technologies)

Part A Annex IX examples

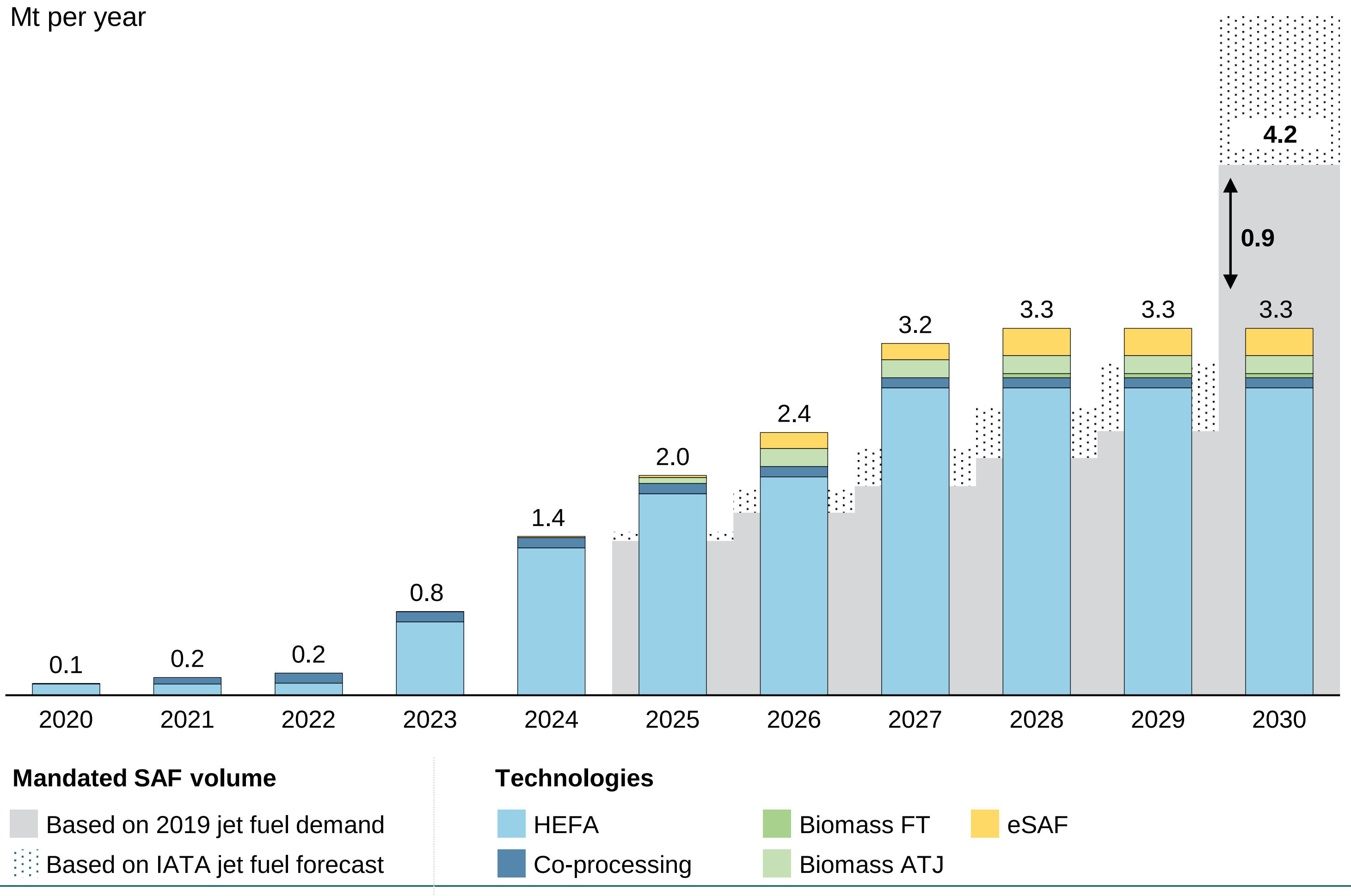
- Animal manure and sewage sludge
- Bagasse
- Biomass fraction from municipal waste
- Biomass fraction industrial waste
- Straw and husks
- Waste and residues from forestry
- Non-food cellulosic material
- Other ligno-cellulosic material

Part B Annex IX examples

- Animal fats categories 1 & 2
- Used cooking oil (UCO)

EU CAN LIKELY MEET 2030 MANDATED DEMANDS, MOSTLY WITH HEFA

SAF demand and capacity EU + UK



Key Takeaways

1. SAF supply will likely meet mandated demand until 2030.
2. The majority of the SAF volumes are from HEFA pathways.
3. Limited volumes from pathways using biomass as feedstock.
4. Advanced biobased pathways will be proven through first of its kind facilities.

Source: SkyNRG Market Outlook (May 2023)

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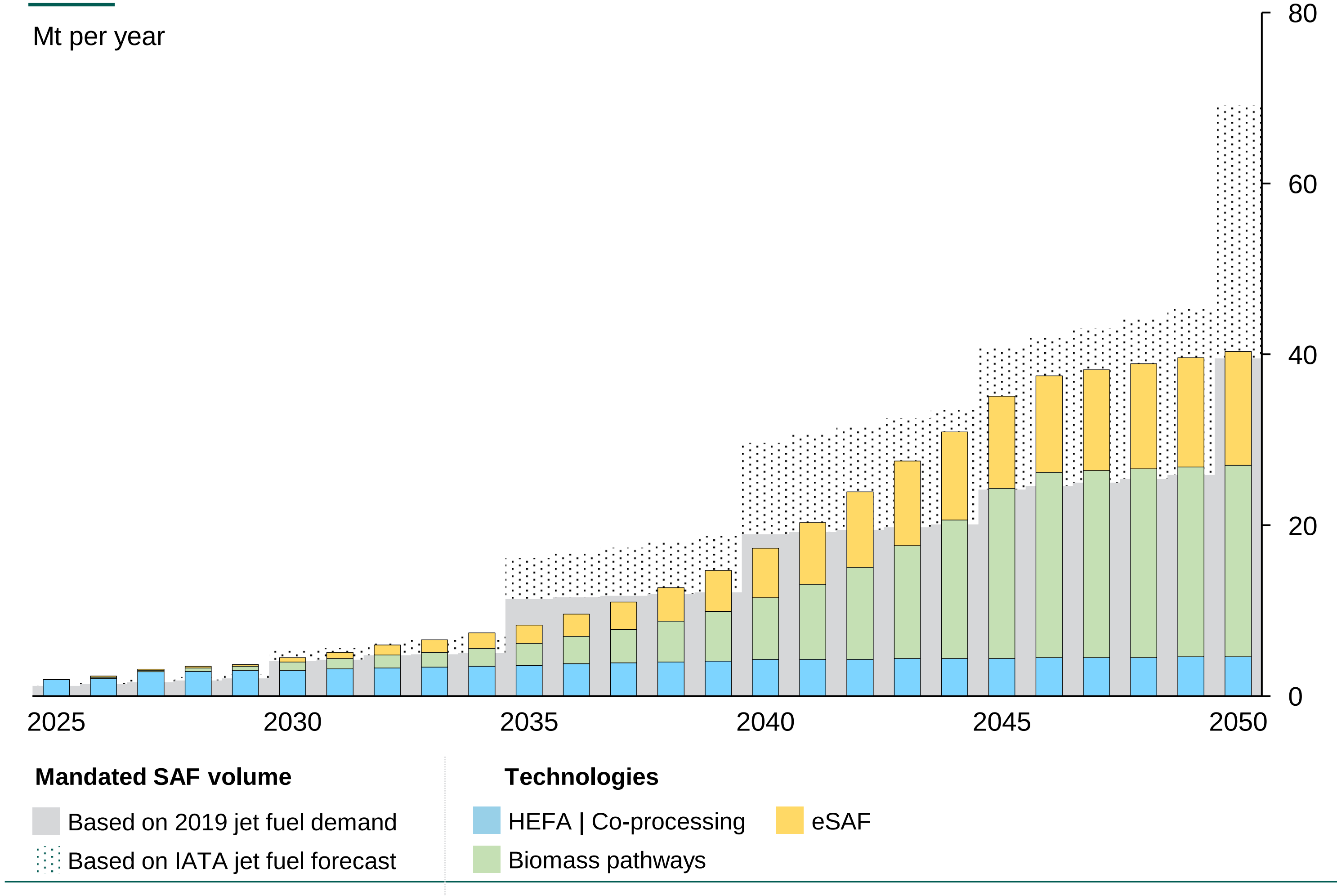
SCALING BIOMASS AND POWER-TO-LIQUID PATHWAYS IS KEY TO MEETING 2050 MANDATED DEMANDS

SAF demand and capacity EU + UK



Key Takeaways

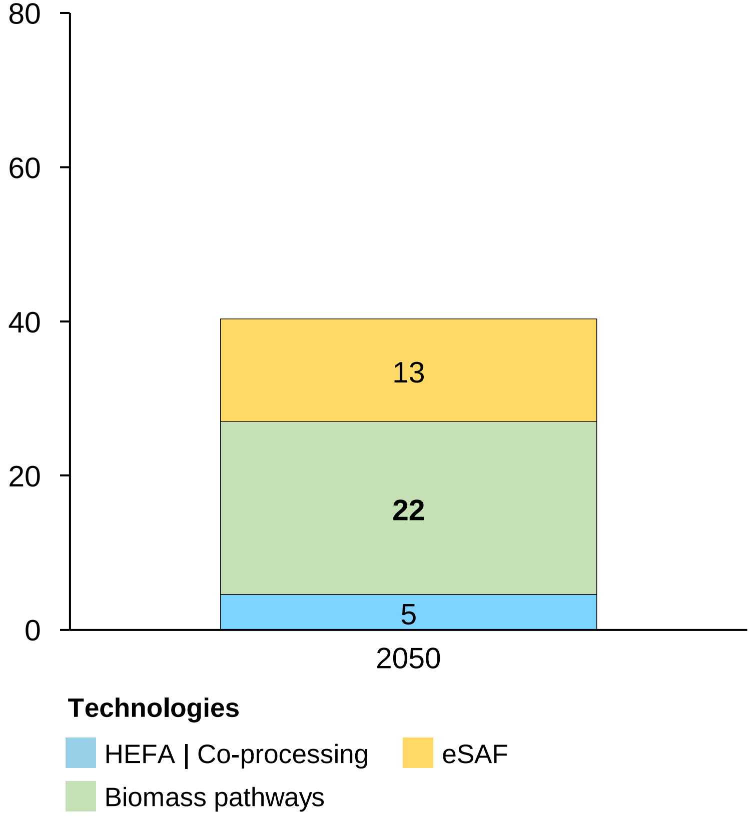
1. Biomass pathways are instrumental to meeting post-2030 targets.
2. Rapid market deployment of bio and PtL SAF dedicated facilities is needed.
3. Jet fuel demand growth above 2019 levels increases pressure on feedstock and reliance on SAF imports.

Source: SkyNRG Market Outlook (May 2023)

AT LEAST A 20% CLAIM IS NEEDED ON THE TOTAL BIOMASS POTENTIAL IN EUROPE TOWARDS SAF PRODUCTION

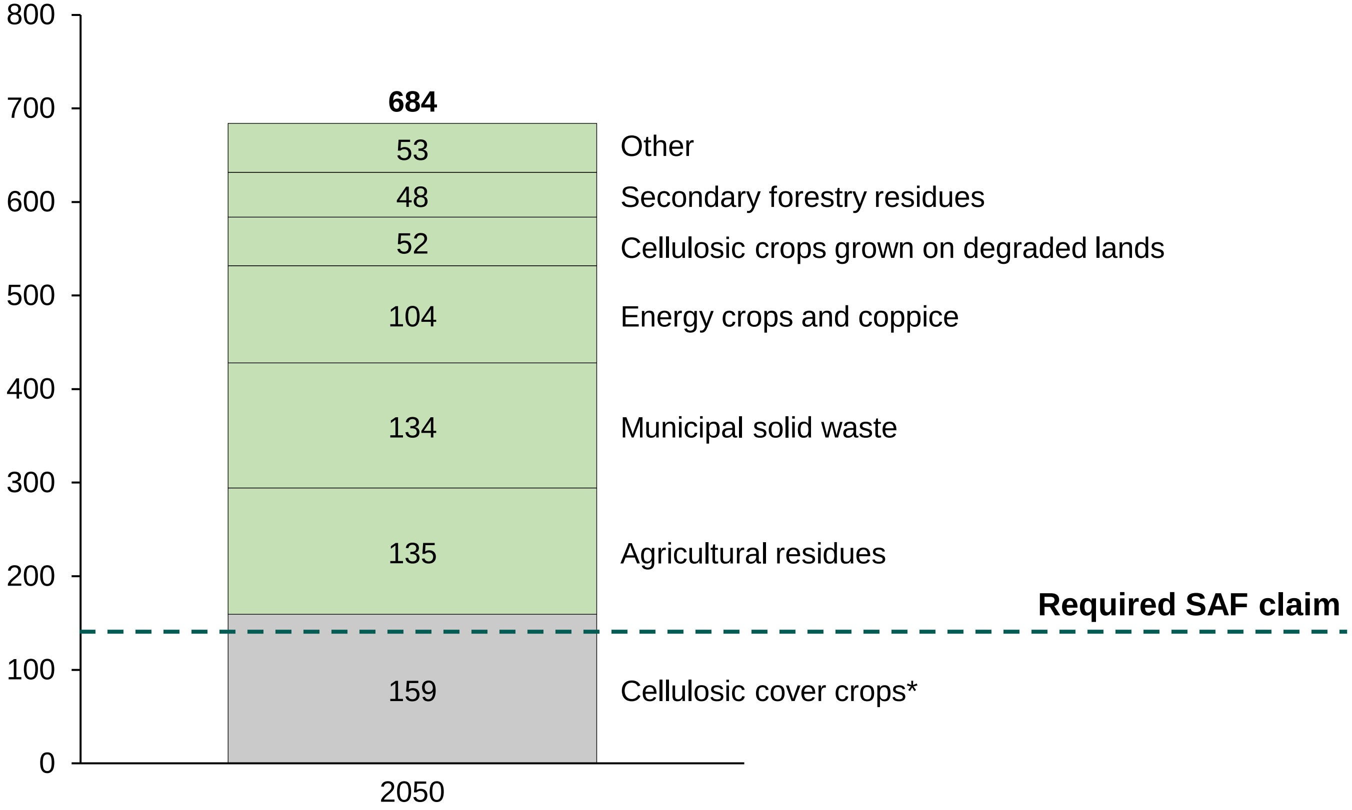
SAF capacity from biomass: >20 Mt / yr

SAF capacity EU + UK
Mt per year



SAF biomass demand requires 20% claim on renewable biomass (> 130 Mt / yr)

Biomass feedstock potential Europe
Mt per year



Source: S2Biom, corrected for logistical constraints in feedstock sourcing
* Note: Cellulosic cover crops are currently considered ineligible feedstock in the RED II, but in the latest suggested amendment, 'Intermediate crops' are placed in Annex IX B.

THERE IS HIGH POTENTIAL FOR BIOMASS IN DECARBONIZATION OF THE AVIATION SECTOR, BUT CHALLENGES MUST BE OVERCOME

Technology Challenges

1. **Effective use of biomass by** increasing feedstock diversity and process flexibility
2. **ASTM certification** of novel pathways requires time
3. **Operation of the first of its kind** commercial scale facilities

Technology development requires time and high-risk investment. **Governments can help de-risk initial investments** to increase the speed of commercial deployment.

Feedstock Challenges

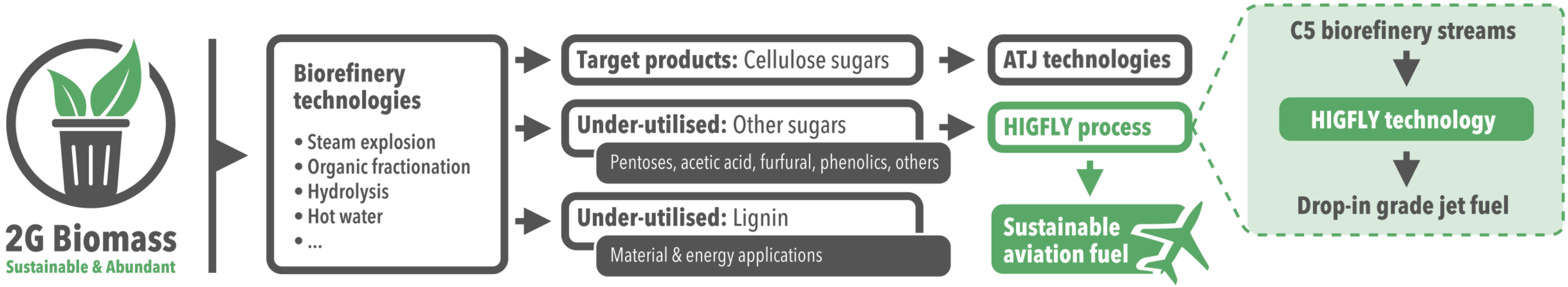
Feasibility of aviation claim on biomass are dependent on:

1. **The willingness to pay** the feedstock price premium
2. **Readiness** of the supply chain

Policies on the production of other bio-fuels and eligible feedstock for SAFs will have a large impact on feedstock competition. **Governments play an important role in the feasibility** of aviation's claim on feedstock.

HIGFLY: HIGEE TO FURANIC-BASED JET-FUEL TECHNOLOGY

HIGFLY valorizes biorefinery waste steams for SAF Production



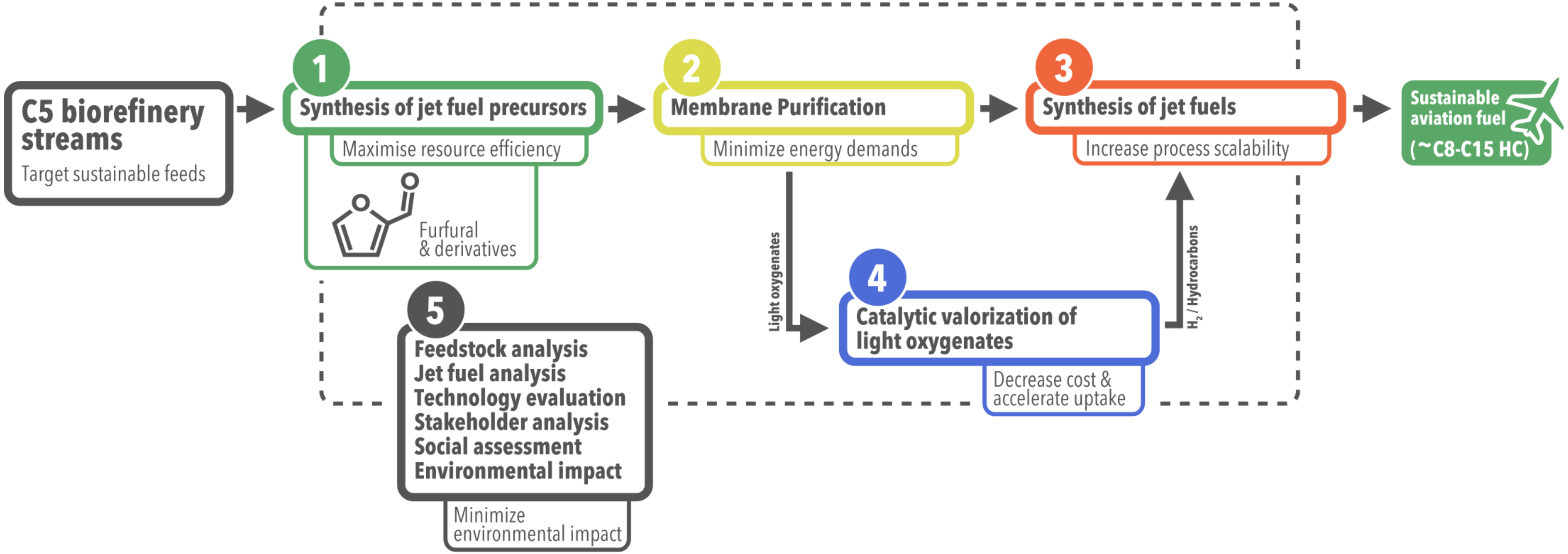
The HIGHFLY project is developing a process to convert **C5 biorefinery waste streams to oxygenated intermediates**.

Oxygenated intermediates are subsequently converted into **jet fuel** through further reactions.

Innovative **catalyst and technologies** are being developed and will be demonstrated.

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N°101006618

HIGFLY: PROJECT GOALS



Scalable catalyst, solvents, reactors, and processes are being developed to increase resource, energy, and cost efficiency. The **carbon efficiency is aimed at 70-90%.**

The process will be demonstrated with a goal of **achieving TRL 3-4**.

The environmental, social, and techno-economic performance is being evaluated to **ensure feasibility and regulatory compliance.**

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