Shell Catalysts & Technologies

The Shell XTL Process

for synthetic aviation fuel (e-SAF) and bio-SAF

Introducing the Shell XTL Process

Sustainable aviation fuel (SAF) is widely recognised as an important lever for decarbonising aviation. Currently, refineries focus on producing bio-SAF from easier-to-process feedstocks such as used cooking oils and animal fats. A key challenge on the horizon, however, is meeting various international mandates and targets, including initiatives like ReFuelEU Aviation, which requires increasing SAF production from more challenging feedstocks, such as biomass residues, and using renewable power and carbon dioxide (CO_2).

In particular, synthetic aviation fuel, also known as eSAF, e-kerosene, PTL kerosene, PTL-SAF or RFNBO-SAF[1], made using power-to-liquids (PTL) technology, has high potential because the feedstocks (solar and wind energy, CO_2 and water) are in virtually endless supply. Combining production of synthetic aviation fuel and bio-SAF can be an enabler for early projects.

The Shell XTL Process (X-to-Liquids, where X stands for anything sustainable, renewable, low-carbon) offers an integrated solution for bio-SAF and/or synthetic aviation fuel production. The process leverages lessons learned from Shell's integrated GTL technology, as applied at Pearl GTL in Qatar, the world's largest integrated GTL facility.

[1]RFNBO: Renewable fuels of non-biological origin

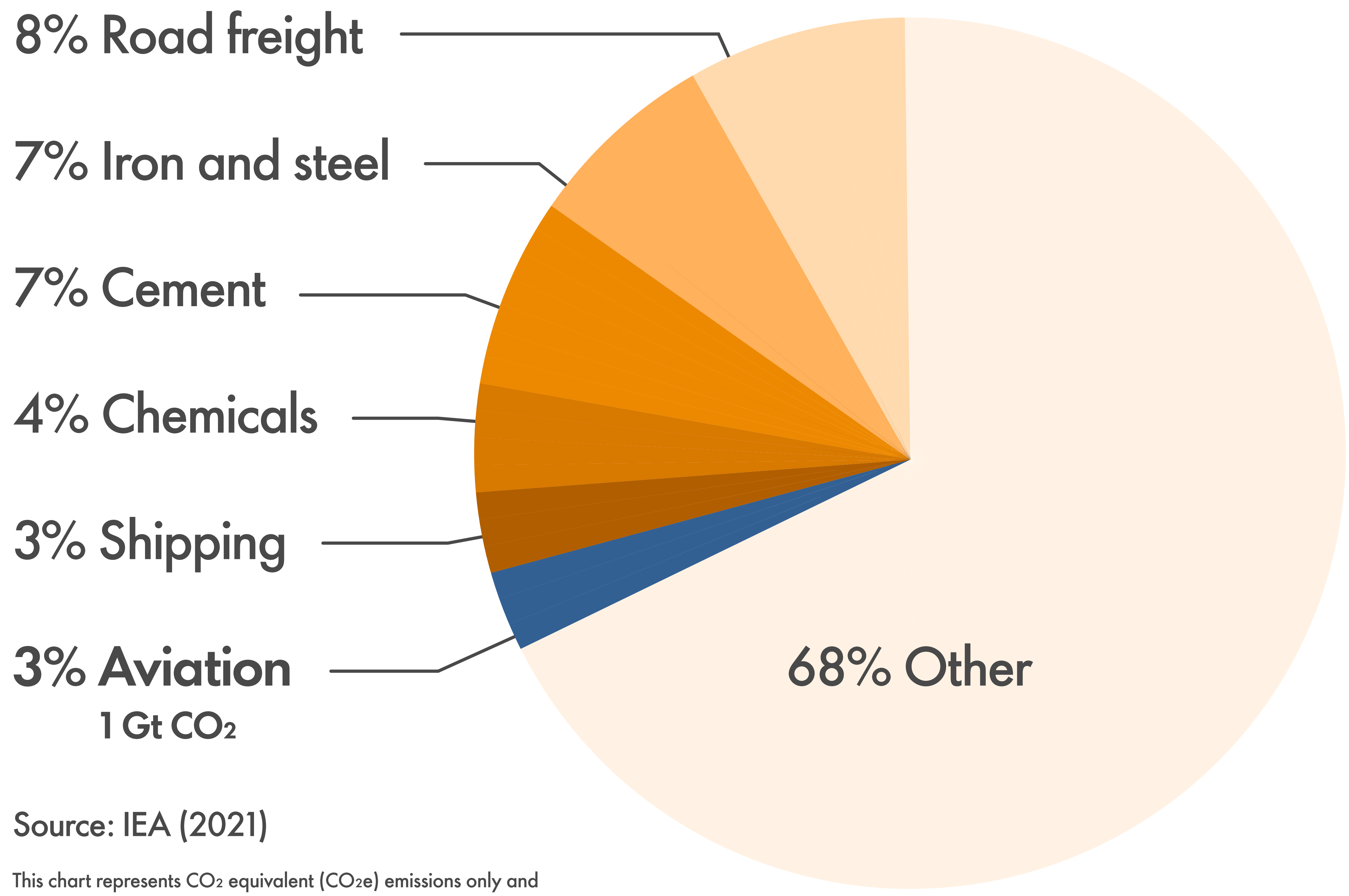
Aviation is one of the fastest-growing sources of greenhouse gas emissions

At present, aviation accounts for a relatively small share of global emissions, viz. 3% in 2019, but estimates suggest it could contribute up to 22% of global carbon emissions by 2050.

Aviation is one of the most challenging sectors to decarbonise due to the long lifespan of aircraft, high cost and limited availability of decarbonisation solutions.

For the foreseeable future, aviation will require drop-in solutions like SAF.

Contribution to global emissions by industry



Source: IEA (2021)

This chart represents CO_2 equivalent (CO_2e) emissions only and does not reflect the non-CO_2 impacts of aviation on the climate.

Aviation's decarbonisation levers and challenges

Reducing fuel consumption

New aircraft can be up to 20% more efficient, but gains can easily be outpaced by growth in activity.

Electric and hydrogen-powered aircraft

New technologies are in development, but challenges like battery weight or hydrogen storage tank size, safety considerations and freight limits make them unlikely to have a significant impact before 2050.

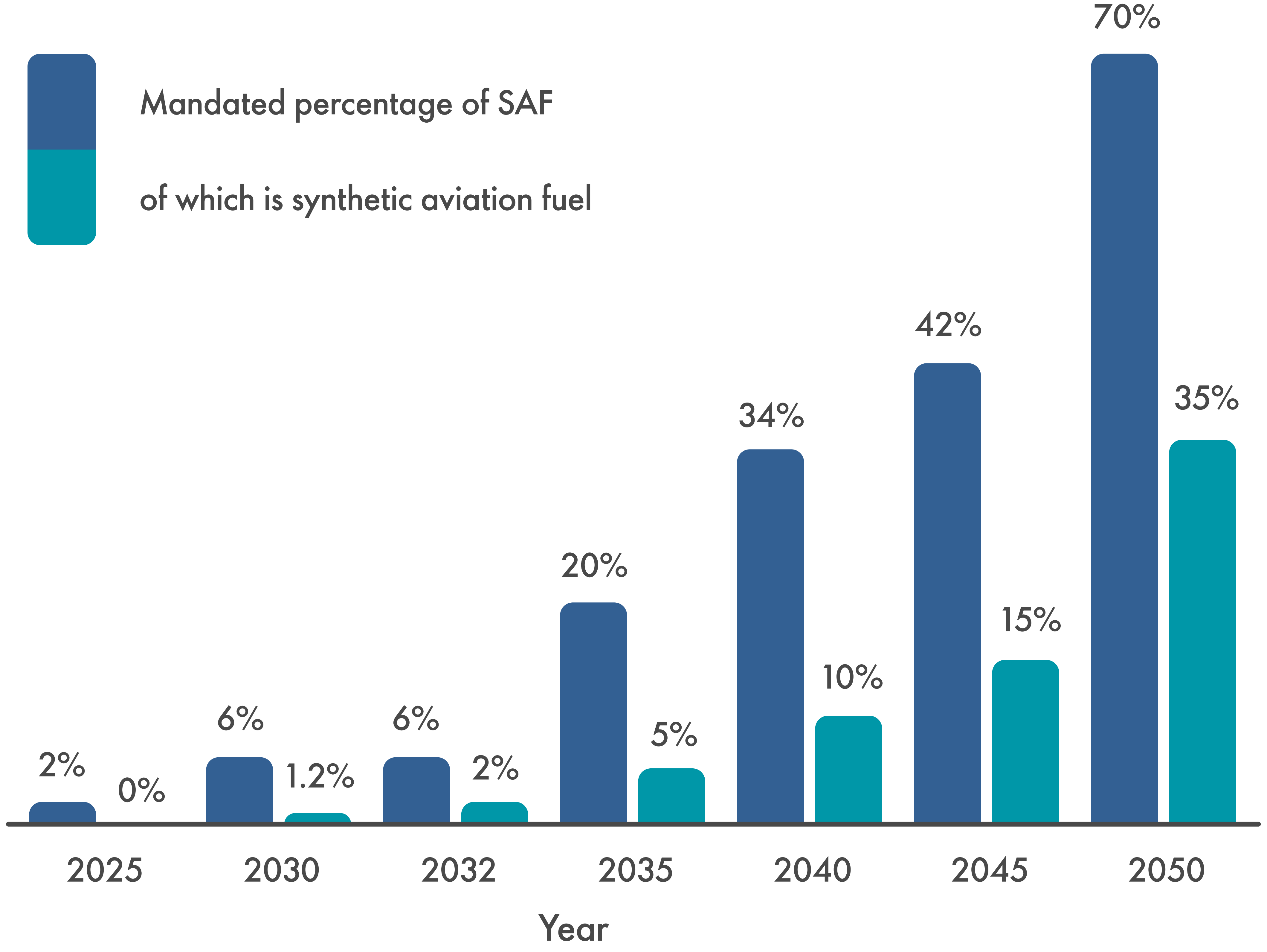
High-quality offsets

These are important for bridging the timing gap as other options are scaled up.

SAF

SAF can be deployed inside of the current aviation infrastructure, but a significant ramp-up of capacity is needed.

Ambitious EU-wide binding shares 2025–2050



Source: European Commission

European regulations are driving demand for synthetic aviation fuel and bio-SAF

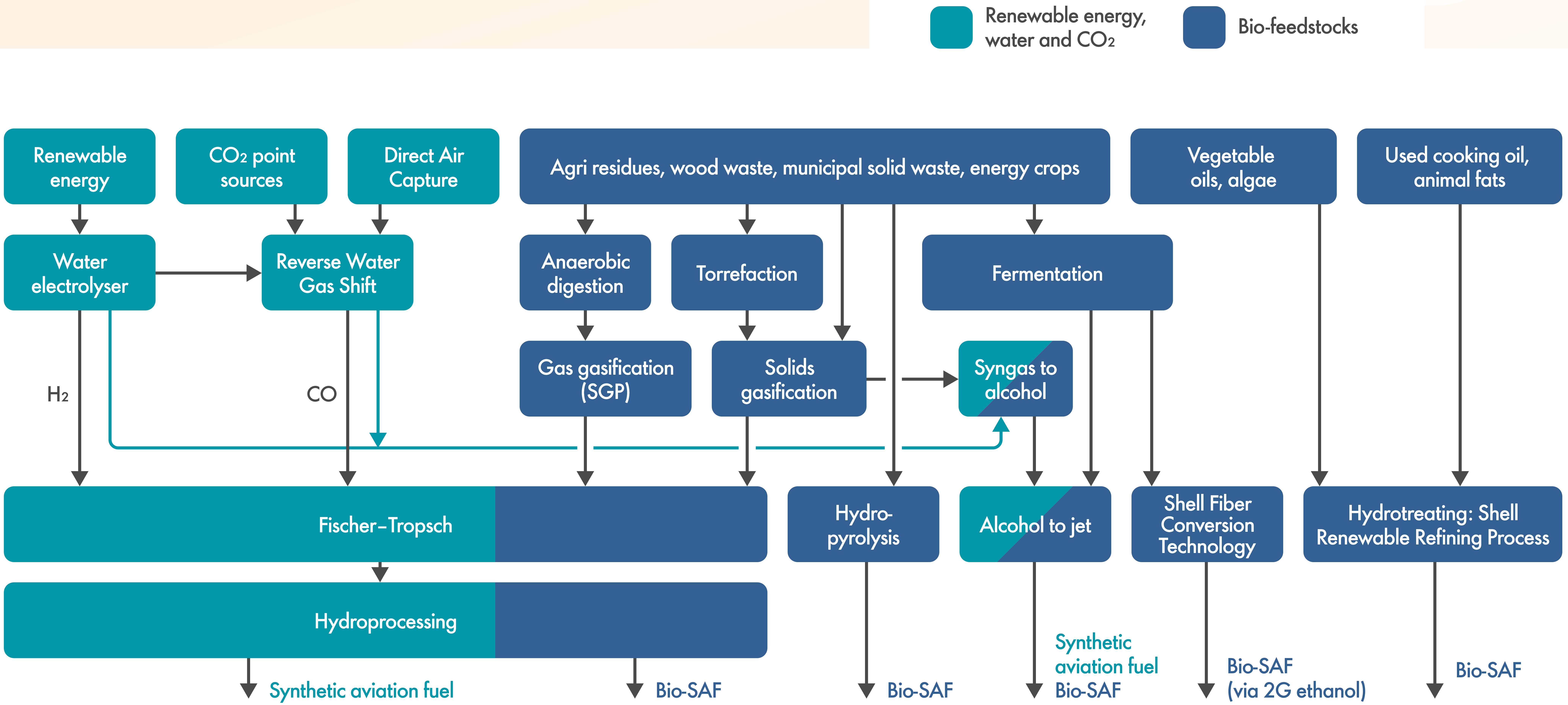
European SAF regulations, which mandate increasing levels of SAF be used in all flights originating in the EU starting in 2025, are driving much of the demand for SAF.

ReFuelEU Aviation is part of the EU's initiative to reduce its greenhouse gas emissions by 55% by 2030 and lays out specific targets for what percentage of aviation fuel must be SAF (from any type of sustainable or renewable feedstocks), and what percentage of SAF must come from renewable (and nuclear) power.

Importantly, importation of SAF is allowed under ReFuelEU; SAF doesn't have to be produced in Europe, just supplied there.

SAF can be made from a wide range of bio-feedstocks

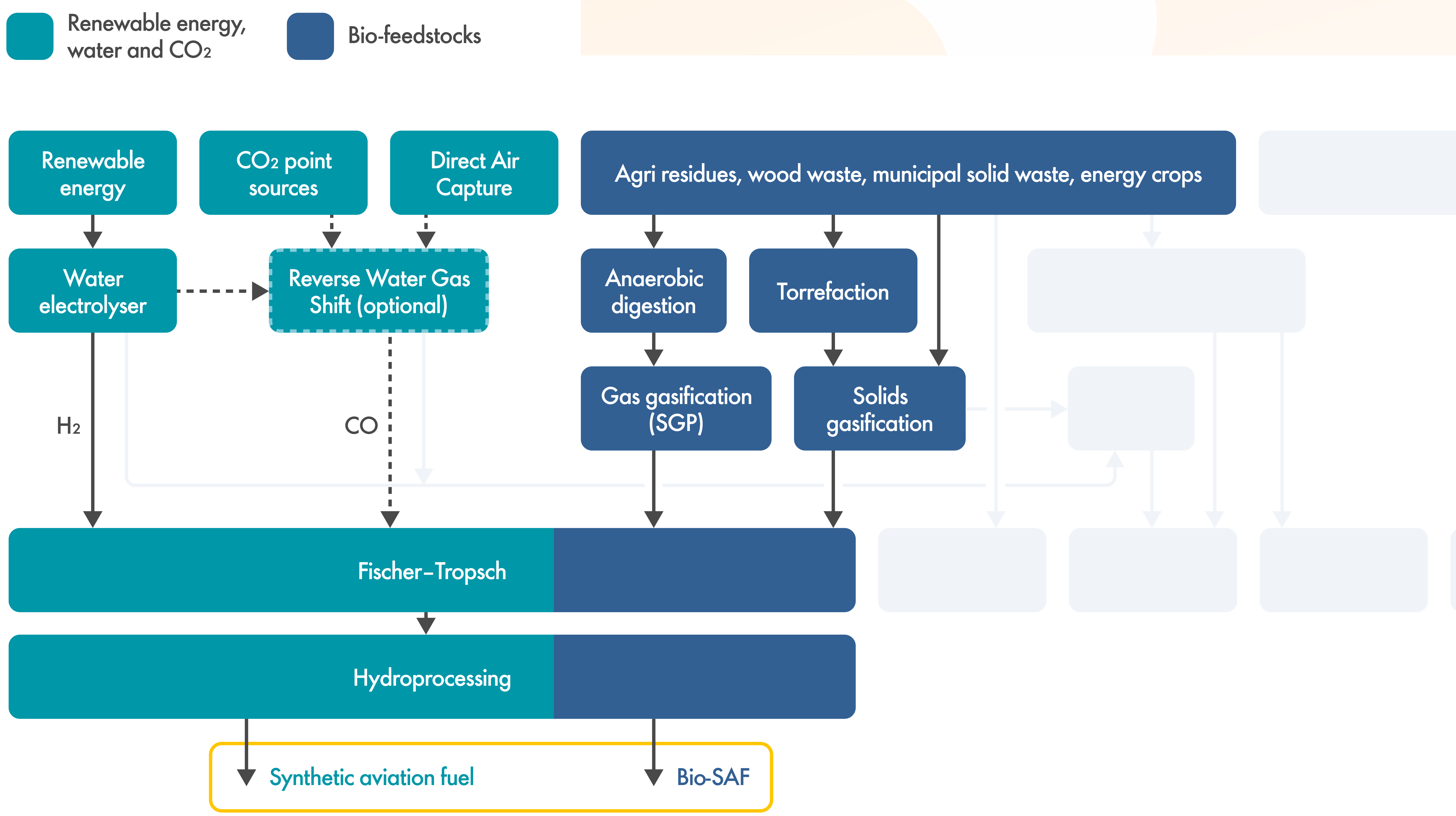
and from renewable energy, water, and CO_2



Co-processing synthetic aviation fuel and bio-SAF has a number of advantages

1. Enables full use of carbon present in biomass
2. Scale of electrolysis is lower, reducing cost
3. Benefit of scale with larger combined Fischer–Tropsch process and hydroprocessing step
4. Lowest cost of making synthetic aviation fuel*

*Subject to implementation of rules set by European regulators

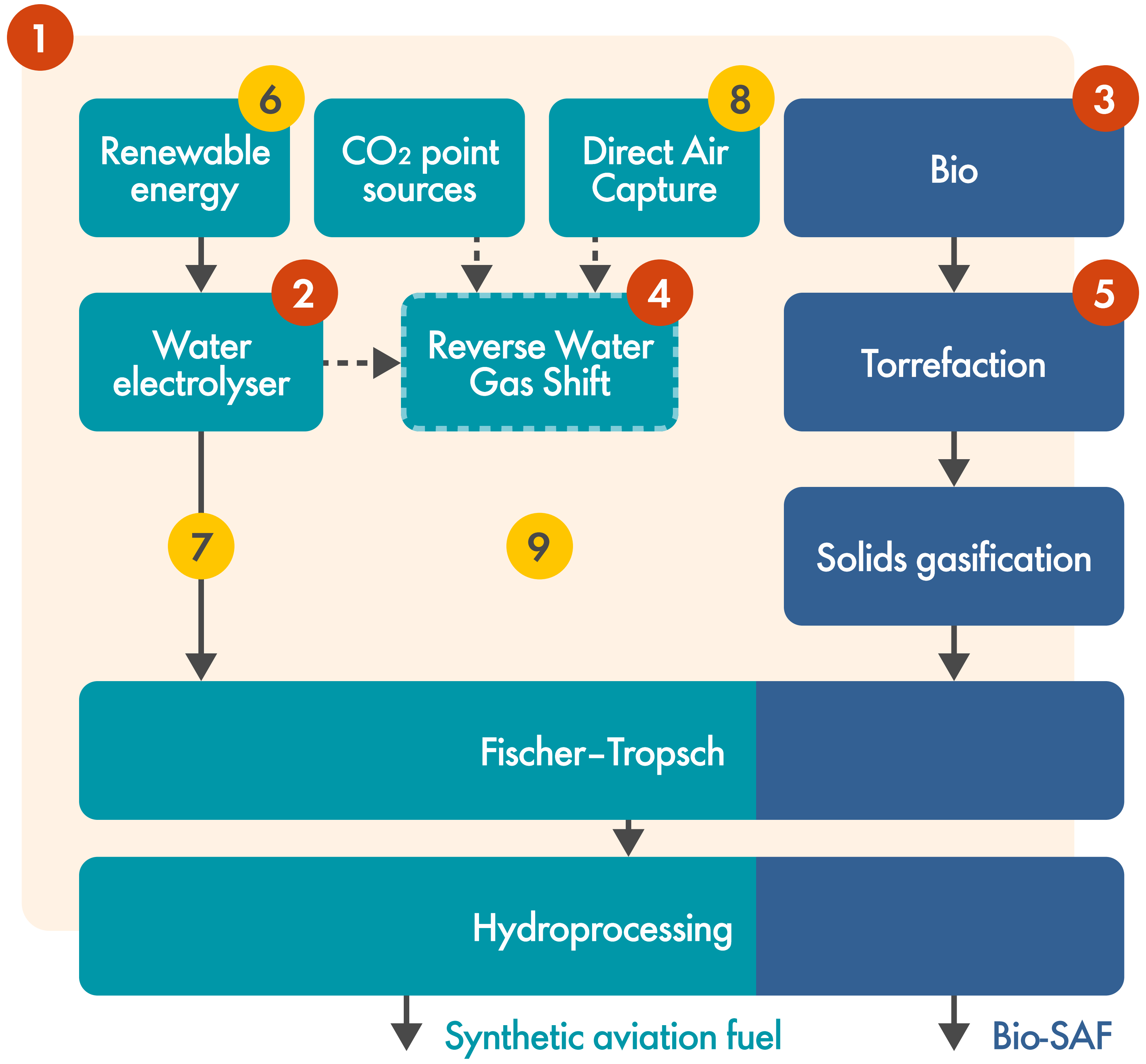


Making PTL viable

Enablers and improvements are needed for Fischer–Tropsch based PTL and BTL/PTL to become economically viable and attractive.

Key enablers for first projects

1. Clear requirements from regulators and customers (power, CO_2, sustainable bio-feedstocks)
2. Water electrolyser available at scale and low cost
3. Affordable sustainable bio-feedstock, established supply chain
4. Technologies for CO_2 conversion to CO need to be fully proven at scale
5. Technologies for preparation and gasification of biomass/bio residue feedstock need to be fully proven at scale



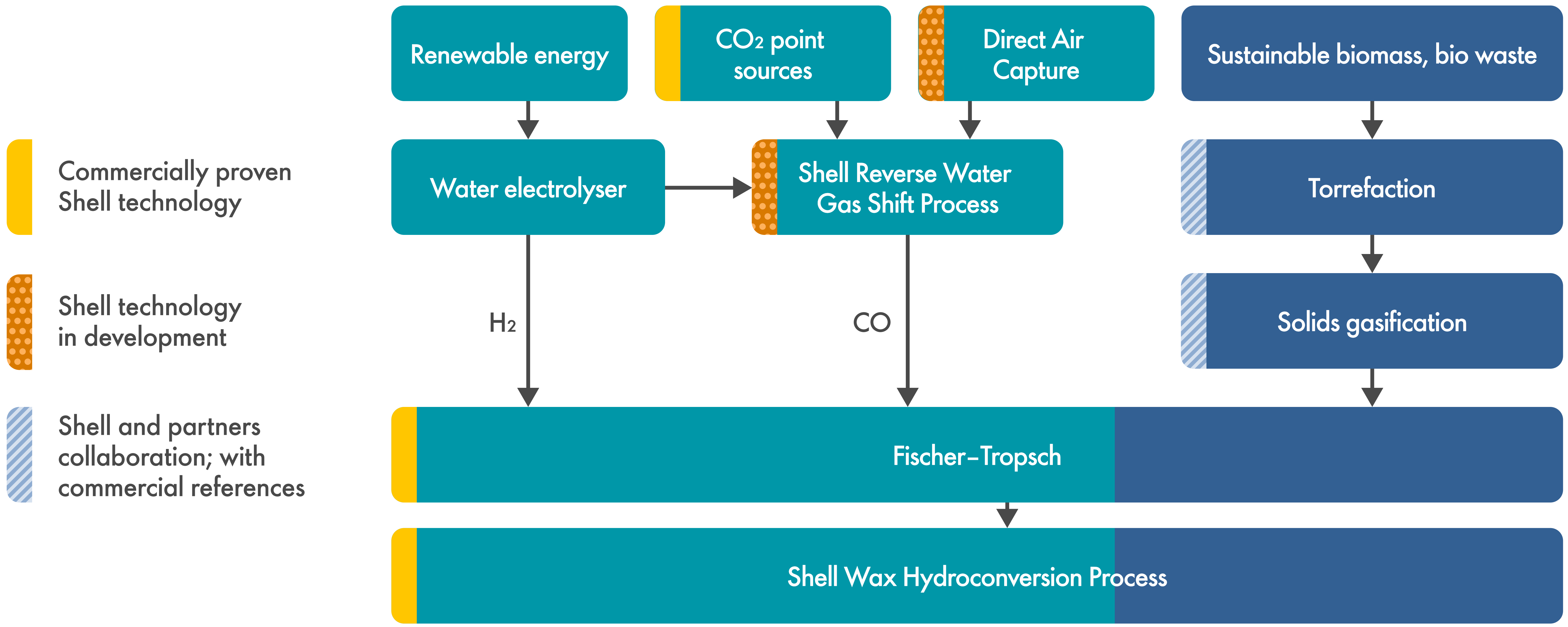
Improvements in progress

6. Renewable power generation at scale and at low cost
7. Storage solutions (hydrogen storage, battery storage)
8. Direct Air Capture (DAC) technology development
9. Optimal integration of all building blocks (process and utilities), including offgas recycle

The Shell XTL Process

The Shell XTL Process* is an integrated solution for producing synthetic aviation fuel and/or bio-SAF using Shell's commercially-proven Fischer–Tropsch technology.

* XTL = X-to-Liquids, where X stands for anything sustainable, renewable, low-carbon



Shell has a track record for developing new and innovative technology

- Deep expertise in GTL/XTL technology, proven on a commercial scale, e.g. Pearl GTL plant in Qatar
- Offshore wind and solar parks in the Netherlands
- Renewable hydrogen plants in Germany (Refhyne), Netherlands (Holland Hydrogen I in Rotterdam, 200 MW) and others
- Market-leading CO_2 capture technologies: The CANSOLV* CO_2 Capture System and ADIP* ULTRA
- Extensive experience in gasification (syngas) technologies, including from gas, liquids and solids

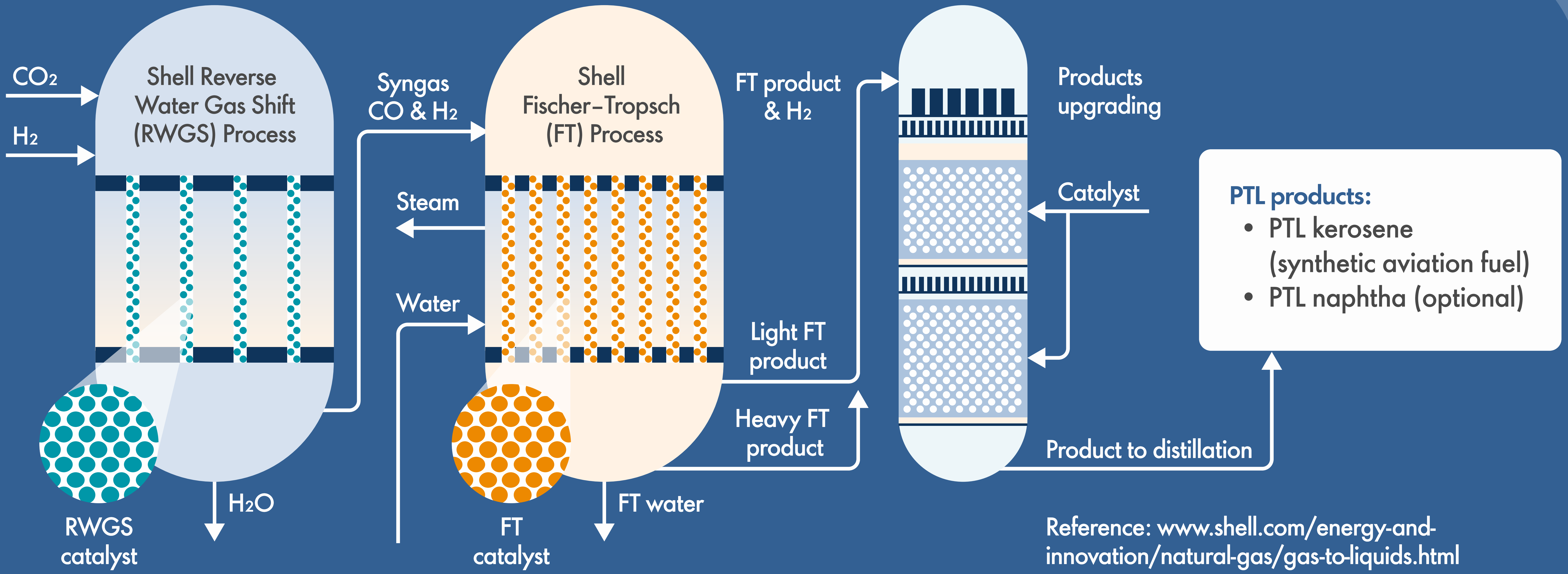
*ADIP and CANSOLV are Shell trademarks.

Technology de-risking activities include:

- RWGS demonstration unit in Deggendorf, Germany (with MAN Energy Solutions)
- DAC demonstration unit in Houston, USA
- Integrated line-up for biomass and waste gasification together with partners
- De-risking intermittent power through integrated process design and operation expertise

PTL: Technology fundamentals

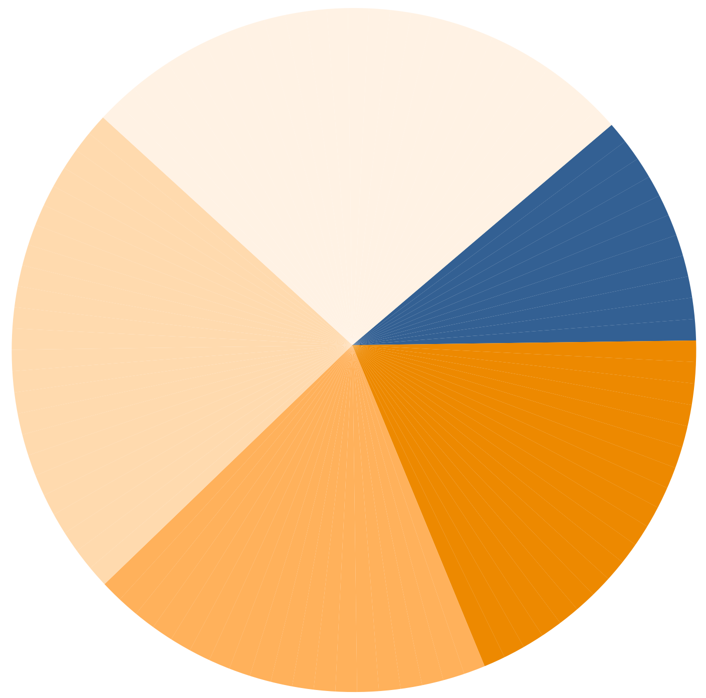
The Shell XTL Process leverages Shell's extensive know-how in Fischer–Tropsch technology and integrated processes and utilities, benefiting from substantial learnings gained over many years of operation at the Pearl GTL plant and continuous developments in GTL/XTL technology.



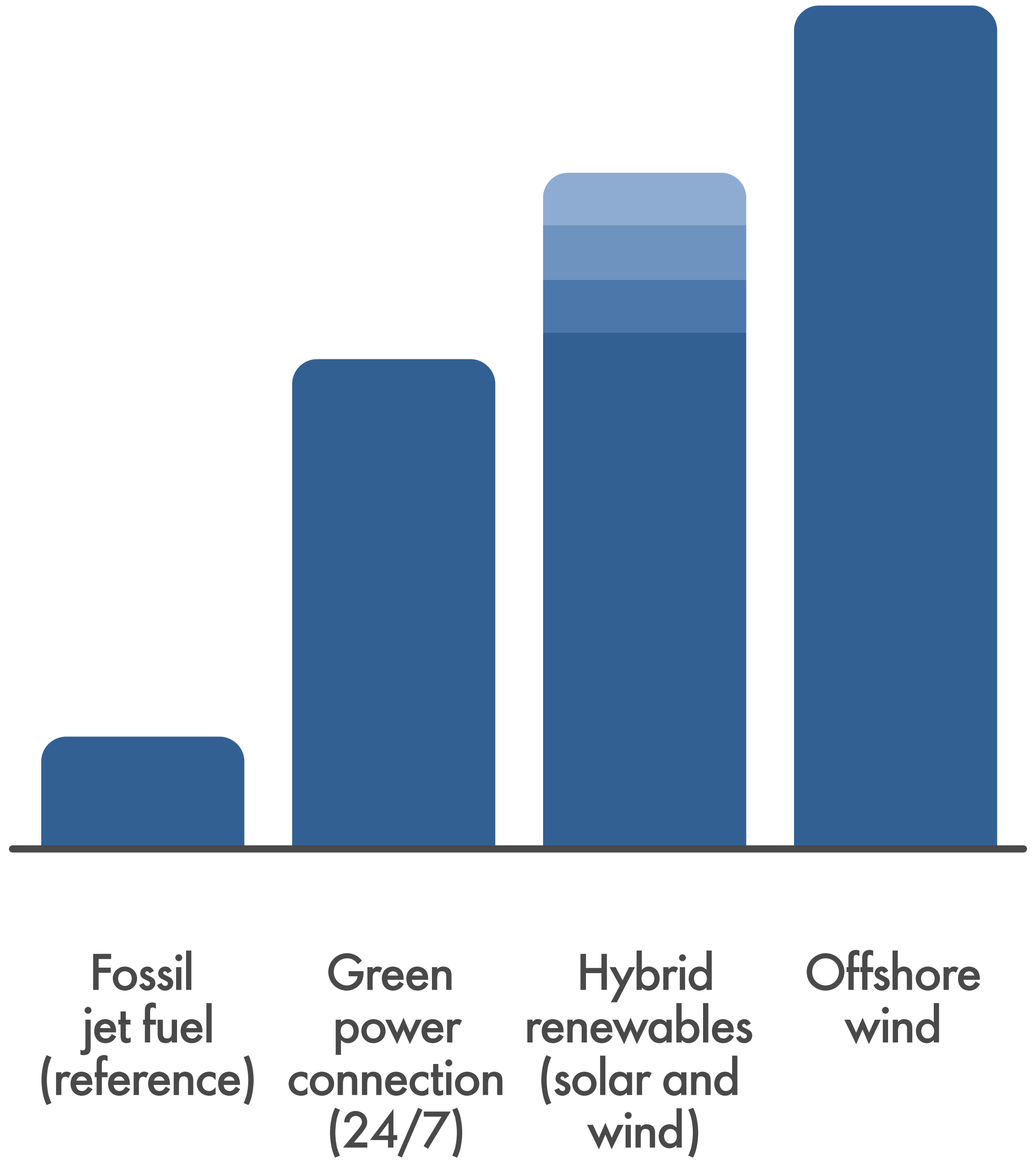
Reference: www.shell.com/energy-and-innovation/natural-gas/gas-to-liquids.html

PTL: Cost component breakdown

Levelised PTL production cost in the Middle East in 2030



Relative PTL production cost in 2030 in $/t(fuel)



The most significant cost components of PTL production are mainly related to renewables, like maintaining a stable supply of renewable hydrogen. Shell recently conducted a case study for a PTL production scenario in the Middle East in 2030. In this scenario, the investment in renewables, electrolysis, and storage would be about four times higher than that in the synthesis plant.

Over time, costs of PTL are expected to decrease due to improvements in technology (especially novel technologies like electrolysers and storage solutions), integrated design and project implementation.

Cost factors are also highly dependent on geographical location. Advantaged locations for PTL include locations with hydropower and regions with complementary solar and wind profiles.

The study also showed that PTL produced as part of combined BTL and PTL is about 30% lower cost.

Proof point: Pearl GTL

Pearl GTL (gas-to-liquids) is the world's largest plant to turn natural gas into other fuels and lubricants with a capacity of 140,000 bpd (or 6 Mtpa) GTL products, also 120,000 bpd natural gas liquids and ethane. The Fischer–Tropsch process is at the heart of the GTL process.

Fully ramped up since 2012, the plant helps to meet the world's growing demand for cleaner energy.

Key takeaways

1 Sustainable aviation fuel (SAF) is widely considered one of the key scalable in-sector options to reduce emissions from aviation in the 2050 timeframe.

2 The combination of synthetic aviation fuel (from renewable power, water and CO_2) and bio-SAF (from biomass residues) offers a number of advantages.

3 The Shell XTL process offers an integrated solution for synthetic aviation fuel and/or bio-SAF, based on Shell's commercially proven Fischer–Tropsch technology.

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Watch the full webinar now

Our on-demand webinar, The Shell XTL process for bio-SAF and synthetic aviation fuel, discusses the Shell XTL process in more detail.

Watch now