KPMG

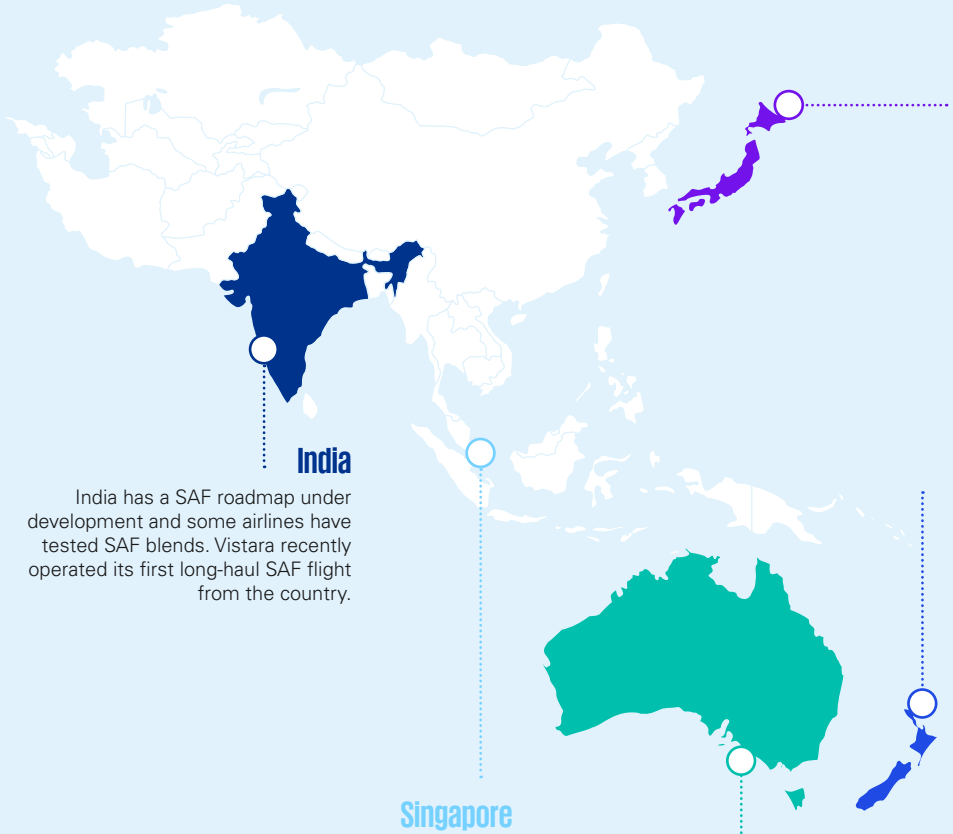
Is Asia Pacific a game changer for the global SAF industry?

Aviation 2030 series

Introduction

To date, most of the sustainable aviation fuel (SAF) activity has taken place in Europe and the United States, but there are a few new kids on the SAF block. Since the beginning of 2023, as local flight traffic has started to rebound after COVID-19 restrictions, Asia Pacific has seen a surge in SAF announcements.

The increasingly favorable local policy environment in Asia Pacific is prompting a number of players to consider opportunities for SAF development in the region. As a result, airlines, airports, investors and fuel producers are increasingly making public commitments promoting the growth of local SAF supply and demand. However,with inherent feedstock limitations and challenges in scaling up more advanced SAF production pathways, the development of a SAF industry in Asia Pacific has the potential to both accelerate and hinder SAF progress in the West.



Japan

Japan established a SAF roadmap in 2021. In May 2023 the government confirmed that, by 2030, 10% of aviation fuel used for international flights at Japanese airports will have to be SAF.

This follows industry progress in April 2023, when locally blended SAF was produced in Japan for the fist time. It was purchased by All Nippon Airways and Japan Airlines as part of a demonstration project sponsored by the government.

India

India has a SAF roadmap under development and some airlines have tested SAF blends. Vistara recently operated its first long-haul SAF flight from the country.

New Zealand

Following a one-year programme run by Air New Zealand, in June 2023 the carrier and the government committed NZ$2m to further investigate the possibility of SAF production in New Zealand.

The next phase of this program will assess the technical, economic, environmental and logistical impacts of two SAF facilities proposed by LanzaJet and Fulcrum BioEnergy.

Singapore

In 2022, Singapore Airlines partnered with the government in a pilot SAF credits scheme. Neste started SAF production in Singapore in May 2023.

In the same month, Jet Aviation announced a partnership with FlyORO, a fuel blending services provider, to offer SAF blends in Singapore.

Australia

A SAF roadmap is currently being developed jointly by the Australian government, Boeing and Australia's National Science Agency. In 2023 LanzaJet announced a feasibility study for an Alcohol-to-Jet facility in Queensland; it has received support from the Queensland Government, Qantas and Airbus as part of a multi-million dollar joint program.

Figure 1: SAF activity in Asia Pacific in the first half of 2023, illustrative examples only; not exhaustive.

All eyes are on China

Several SAF announcements were made across Asia Pacific in the first half of 2023, as set out in Figure 1. Government trials, funding and developing mandates are prompting an increasing number of fuel producers and airlines to look at SAF. Market entry opportunities in the region are growing, and Asia Pacific is becoming increasingly attractive for both SAF production and offtakes.

SAF activity may boom in China in particular. Until early 2023, the only notable SAF production in the region was Sinopec's facility outside Shanghai, which delivers fuel to the Airbus Delivery Centre in Tianjin.[1] In April 2023, Cathay Pacific committed to developing four power-to-liquid production facilities in China alongside the State Power Investment Corporation – one of the five large state-owned energy companies in the country.

China's track record in rolling out wind and solar energy, as well as transport infrastructure more widely, has demonstrated the country's ability to move quickly once it decides to adopt a technology solution. If the four facilities backed by the government are delivered between 2024 and 2026 as planned, commercial SAF production in China could could kick-start earlier than in European countries where the approach to SAF incentives is still being refined, such as the UK. Peking University's Institute of Energy estimated that China could produce 150 kt of HEFA in 2022, but this could ramp up to around 2 million tons by 2025 if existing production of hydrotreated vegetable oil, used for road transport, is switched to SAF.[2]

1. Airbus, 2022: Airbus and partners embark on SAF deliveries in China
2. Institute of Energy, Peking University, 2022: The present and future of sustainable aviation fuels in China

The speed at which pivoting renewable fuels from road transport to aviation will happen in China will depend on several factors, including the rate of passenger vehicle electrification (already one of the fastest in the world), the use of low carbon fuels in heavy duty vehicles and the availability and attractiveness of any local renewable transport fuel subsidies. Nevertheless, there is great potential for scaling up hydroprocessed esters and fatty acids (HEFA) fuel – the most commercial SAF available to date – and this is on top of a significant potential for scaling a domestic power-to-liquid (PtL) SAF[3] industry (see below).

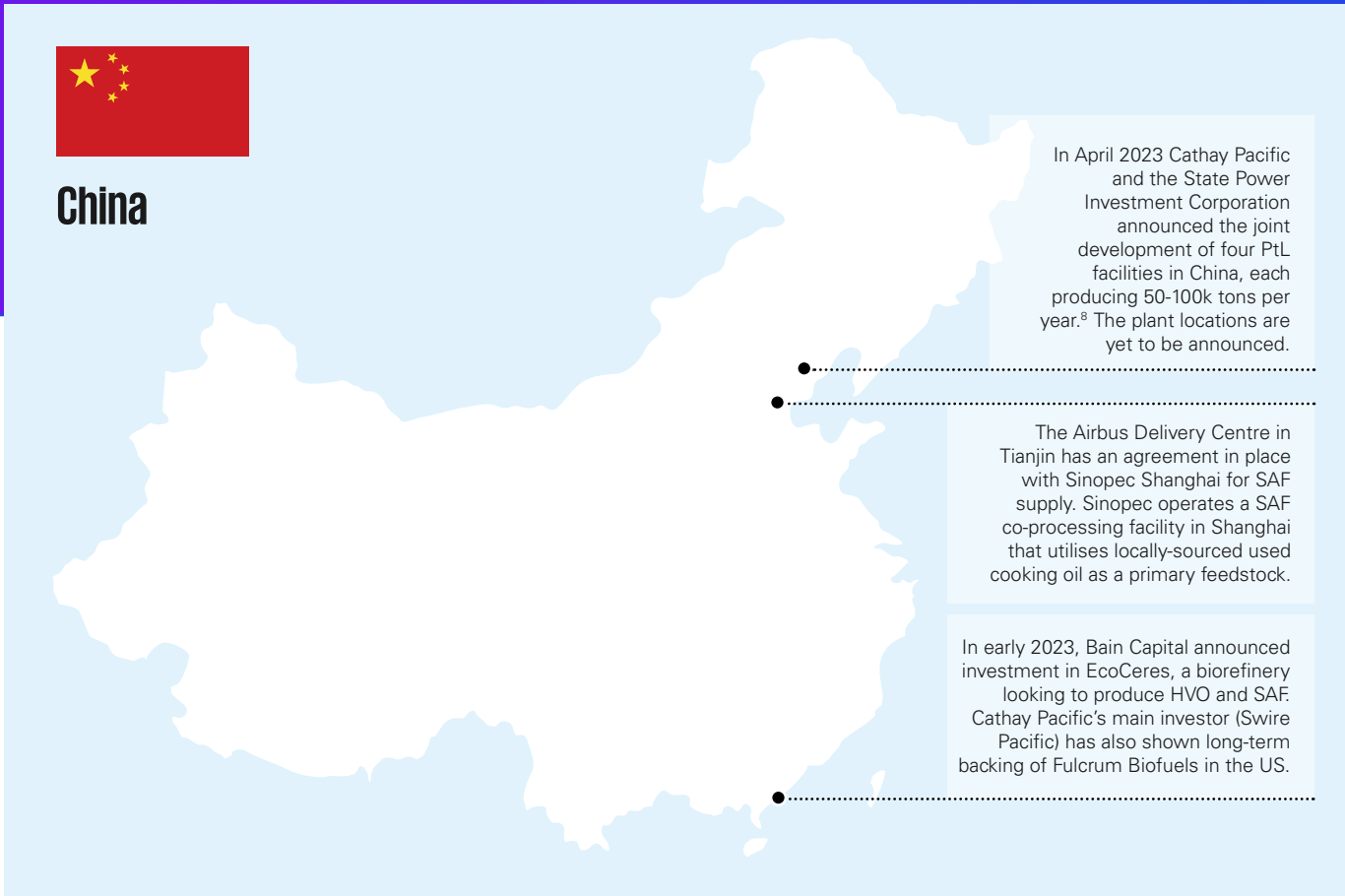


Figure 2: Illustrative map (not comprehensive) of recent SAF activity in mainland China.

An increase in SAF demand from Chinese airlines would accelerate the potential rapid expansion of SAF production capacity in China even further. As of mid-2023, the Chinese aviation sector is still recovering from COVID-19 restrictions. Jet fuel consumption in 2023 is expected to still be 10-30% below the 2019 pre-pandemic level.[4] In addition, very few Chinese carriers have made public commitments to SAF. However, the Civil Aviation Administration of China has recently mandated the use of 50,000 t of SAF in China by 2025[5] - roughly equivalent to 0.1% of the total jet fuel used in the country in 2019[6], or the fuel consumption of a thousand flights between London Heathrow and Shanghai Pudong. At present, this is a small step; however, further ambitious targets are likely to follow within the Chinese market.

3 Power-to-liquid traditionally refers to fuels obtained from the combination of carbon dioxide and hydrogen. These are also known as e-fuels.
4 S&P Global, 2023: China's crude throughput to fall
5. China Dialogue, 2023: Policy support needed to boost sustainable aviation fuels in China
6. Keep existing reference but replace link with S&P Global, 2023: China's open borders do little to boost oversupplied Asian jet fuel/kerosene market

Feedstock availability

Increasing global SAF demand will drive increased feedstock requirements; at the same time these feedstocks will also be needed for renewable diesel production.

As a result of the expected SAF market growth, the IEA expects demand for vegetable oil, waste and residue oils to increase 50% between 2022 and 2027, although growth rates may be even higher when more recent SAF industry and policy developments are factored in.

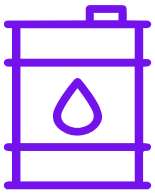
Such feedstock, however, is not evenly available across the globe. To date, many countries in Europe have produced renewable fuel for either road transport or aviation relying on large volumes of feedstock imported from Asia.

Feedstock imports in numbers

Nearly half of the renewable transport fuel supplied to the UK in 2022 was produced from used cooking oil, over a third of this came from China.[7]

China supplied over a third of the used cooking oil imported to Europe in 2020.[8]

In Spain, 1 in 5 of the feedstock used to produce renewable diesel came from China.[9]



Indonesia and Malaysia produce one third of the world's vegetable oil and are responsible for half of the world's exports.[10]

We expect Europe's historical reliance on oil feedstock imports to continue in the short term. At present, access to vegetable oils for fuel production in the continent remains disrupted by the Ukraine war, and alternative waste-to-fuel or PtL pathways are still scaling up. To meet increasing renewable fuel targets for road transport and developing SAF mandates, many European countries will likely continue to look at Asia for feedstocks.

However, feedstocks in Asia are also limited.[11] If these are prioritized for local SAF production, European supply chains could be severely disrupted. This can impact feedstock prices and may add further pressure to the overall global feedstock shortages (discussed at length in our previous paper).

Non-export dependent markets like the US and Brazil, where SAF policy is inherently linked to domestic crops - putting aside for the moment serious concerns around the long-term sustainability of intensive monocropping - may be better off. The US Renewable Fuel Standard (introduced in the early 2000s to support the growth of renewable fuels for road transport) displaced nearly two billion barrels of foreign oil in its first ten years of operation.[12] This trend is likely to continue as new incentives for the US SAF industry are rolled out, including tax credits under the Inflation Reduction Act. These are expected to provide a major boost to domestic fuel production that could further insulate the country from global feedstock shortages.[13]

7. DfT, 2022: Renewable fuel statistics 2022: second provisional report
8. Transport&Environment, 2021: Europe's imports of dubious 'used' cooking oil set to rise, fuelling deforestation
9. European Parliament, Parliamentary questions, 2022: High imports of used cooking oil from China to Spain
10. S&P Global, 2023: Supply vs sustainability a key challenge for palm oil industry
11. ICCT, 2022: An estimate of used cooking oil from Asian exporting countries

Feedstock sustainability and standards

Availability is not the only feedstock issue. Sustainability concerns associated with importing fuel feedstocks from the East regularly make headlines.

NGOs have frequently reported concerns around deforestation linked to palm oil in Malaysia and Indonesia, as well as the validity of used cooking oil from China.[14] In April 2023, the International Sustainability and Carbon Certification (ISCC) performed extra audit checks following suspicious feedstock activity.[15]

Some of these risks have been historically mitigated by the introduction of caps and tighter standards in Europe. However, the provisional RefuelEU agreement reached by the European Council and Parliament in April 2023 opens the door to a broader list of biofuels than initially envisaged by the Commission,[16] which may weaken the potential for carbon emission savings.[17] Increasing demand for feedstocks for direct use in Asia may exacerbate sustainability risks in the region further, due to historically more relaxed sustainability criteria compared to Europe. This could have knock-on consequences on the sustainability, and thus the reputation, of renewable fuels in the continent too.

Sustainability of renewable fuels is a particularly hot topic in Europe, where, as an example, there have already been disputes over the treatment of palm oil fatty acid distillate (PFAD). This is considered as a bi-product of palm oil in the UK, Sweden and Germany, but treated as a residue (and thus eligible for renewable transport fuel certificates) in Finland (home of Neste) and France. Airlines and alliances that include multiple carriers will have to consider how SAF targets could be met using fuels from across regions and how such SAF choices could be perceived by the public.

Increasingly different sustainability standards may give long-haul airlines presentational headaches, as well as complicate administrative efforts to comply with legislation and mandates. The sustainability standards of the proposed UK mandate, RefuelEU package and the US's Inflation Reduction Act are already quite different, with the first two focusing on waste and the latter potentially supporting local crop production.[18] Local governments looking to implement policy and regulation to scale up SAF in Asia will need to strive for synergy and consistency, and take into consideration lessons learned from other countries to avoid sustainability backlash.

14. Transport&Environment, 2021: Europe's imports of dubious 'used' cooking oil set to rise, fuelling deforestation
15. Argus, 2023: ISCC responds to suspected biodiesel mislabelling
16. European Council, 2023: Council and Parliament agree to decarbonise the aviation sector
17. ICCT, 2022: Considerations for the ReFuelEU aviation trilogue
18. Reuters, 2023: US ethanol industry expands focus to lower-carbon aviation sector

Power-to-Liquid fuels dependencies

Our previous paper 'Sustainable Aviation Fuel: Ready for lift off?' concluded that one way to tackle the increasing feedstock issues in Europe, where crops grown for direct use in SAF are not currently allowed under mandates, is to ramp up production of PtL or electro-fuels.

While in April 2023 the EU announced that e-fuels will continue to be permitted for new car sales after 2035, we do not expect this regulation to divert significant volumes of e-fuels away from the aviation market. Conversely, higher demand for e-fuel across transport modes could accelerate the commercialization of PtL production.

However, the sustainability of this production pathway is contingent on the use of green electricity from electrolysis. Therefore, to unlock greater PtL capacity, electrolyzer manufacturing will need to scale up. This could paradoxically exacerbate Europe's dependency on Asia even further, as Asia Pacific is at the forefront of the hydrogen electrolyzer manufacturing industry. While Europe is ramping up electrolyzer manufacturing capacity, nearly half of the electrolyzers manufacturers' headquarters were based in China in 2022.[19] Japan is planning to introduce 15 GW of electrolyzers by 2030, covering 10% of the world's demand.[20]

Electrolyzers raw materials supply chain

Nickel is the main component of both the anode and cathode in alkaline electrolyzers – the most common electrolyzers alongside proton exchange membrane technology. Industry engagement has also highlighted the role of nickel as a potential replacement of platinum in proton exchange membrane electrolyzers. Alongside Australia, Indonesia has one of the world's largest nickel reserves and raw nickel ore cannot be exported from the country without local processing and refining. The Philippines, New Caledonia and China also have significant nickel reserves.[22,23,24,25]

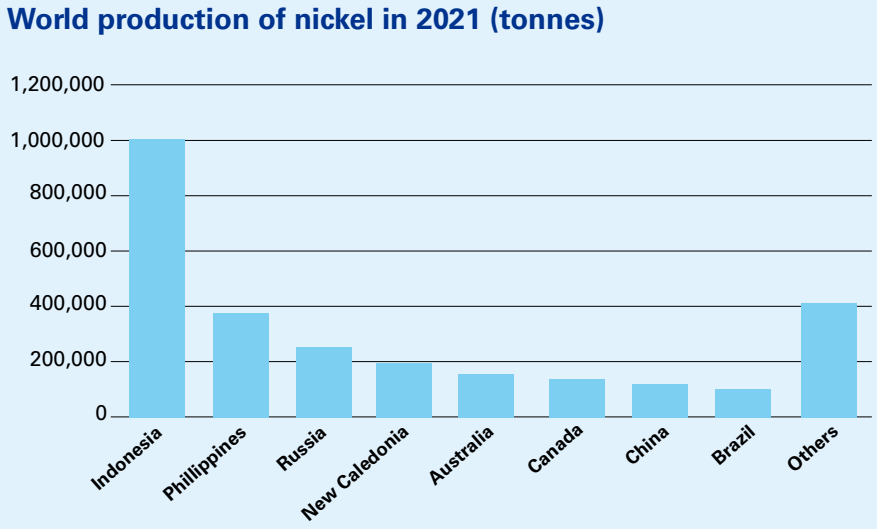


Figure 3: World production of nickel in 2021, with data from USGS[26]

If Asia moves to scale up PtL quickly alongside established SAF pathways like HEFA, Europe's ambition to quickly ramp-up PtL as an alternative pathway to other biofuels could also be affected. This is because Europe will need increasing access to electrolyzers or raw materials that, at current rates of growth, may be more easily scaled up outside the continent. KPMG engagement with projects looking to deploy hydrogen electrolyzers in Europe has also highlighted the persistence of supply chain challenges that could affect the timely production of green hydrogen in the region. Western governments will need to monitor raw material availability, electrolyzer production activity and supply chain challenges and design interventions that could reduce dependency from the East.

19. Scottish Government, 2022: Assessment of electrolysers: report
20. Jdsupra, 2023: Japan unveils green subsidy programme – can it compete with the U.S. Inflation Reduction Act?
21. The Economist, 2023: Indonesia's nickel boom tests Western green sensibilities
22. S&P Global, 2021: Philippine nickel mining to post increased 2021 production, despite heavy rains
23. Reuters, 2021: Explainer: How the New Caledonia government collapse may affect the nickel market
24. Australian Government, Earth sciences for Australia's future: Nickel
25. Lowy Institute, 2023: Indonesia's uncertain climb up the nickel value chain
26. Mineral Commodity Summaries, USGS, 2022: Nickel

Accelerated PtL deployment?

Asia's investment in electrolyzers, however, also provides potential upsides for the global SAF market.

History has shown that China's involvement with highly replicable technologies, such as solar and wind, has resulted in incredibly fast cost reductions and accelerated deployment that may have once been considered unthinkable. The cost of a solar panel module dropped by 85% between 2010 and 2020.[27] Large scale production and automation, cheaper labor and heavy government involvement in China have all been proposed as key drivers behind cost reduction, increased efficiency, carbon emissions reduction during manufacturing and process innovation in solar modules.[28,29,30,31] As a result, over 90% of today's solar product market is controlled by China.[32]

While the learning effects associated with certain SAF production pathways are less certain (the World Economic Forum estimates gasification+Fischer-Tropsch will only see a 20-30% cost reduction through to 2050), PtL is widely considered by the aviation industry as the pathway with the greatest cost reduction potential, with a two thirds drop in cost expected by 2050.[33]

If China's investment in electrolyzers manufacturing capacity unlocks the cost reductions seen with other renewable energy technologies, then Europe could benefit from access to increasingly cheaper electrolyzers.

Europe's ability to translate this to competitive PtL fuel costs, however, will ultimately rely on the cost of the other main inputs i.e. electricity and carbon. Taking industrial electricity prices as a reference, most of European PtL currently does not look cost competitive with other regions, including China and the Middle East. Europe may, however, retain a sustainability advantage in the short term as the average carbon footprint of the electricity grid in China is significantly higher (and hence the hydrogen and the PtL produced from it could technically be 'greener'). This could change in the future as China has the largest renewable energy pipeline in the world.

Indicative assessment of Power-to-Liquid potential

Indicative visualization of countries' Power-to-Liquid fuel production potential based on retail electricity prices and renewable energy generation

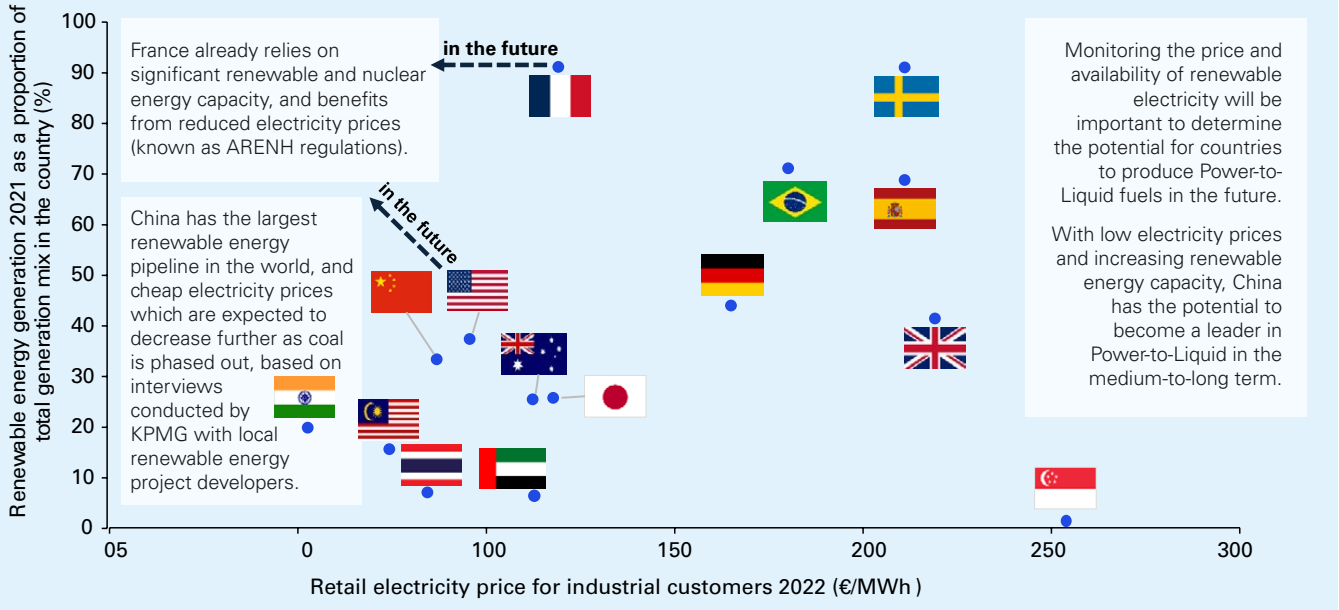


Figure 4 – Retail electricity prices vs renewable proportion of electricity generation. Renewable energy generation includes wind, solar, hydro and nuclear. KPMG analysis. Some of the prices indicated here may be affected by the disruptions to global energy markets between 2021 and 2022. As prices begin to fall, the competitive positioning of countries in this chart may change.

27. NREL, 2021: Documenting a decade of cost declines for PV systems
28. Financial Times, 2021: Is solar manufacturing a highly automated business?
29. MIT, 2013: A duel in the sun
30. ITIF, 2020: The Impact of China's Production Surge on Innovation in the Global Solar Photovoltaics Industry
31. IEA: China currently dominates global solar PV supply chains
32. Goldman Sachs, 2023: China may reach energy self-sufficiency by 2060
33. World Economic Forum, Clean Skies for Tomorrow, 2020: Sustainable aviation fuels as a pathway to net-zero aviation

Conclusions: what to monitor in the market

Following increasing government and industry activity in Asia Pacific in the first half of 2023, we expect to see, in the coming months:

- more widespread introduction of SAF policy, mandates and incentives – these could increase the financial attractiveness of producing SAF in Asia Pacific compared to other regions, but could create a patchy or inconsistent policy framework that could stifle competitiveness if not implemented collaboratively;
- an increasing number of SAF trials and commitments from airlines active in the Asia Pacific region – these could increase demand for SAF globally and exacerbate competition for sustainable fuel molecules, both locally and in other regions where such airlines fly to/from, but could also increase opportunities for renewable fuel producers and suppliers to secure offtake agreements;
- growing SAF production activity from both oil and gas majors and smaller, local project developers - these could accelerate the commercialization of certain SAF production pathways globally, with implications on cost reductions and technology exports, but could also affect feedstock availability and trade flows between countries.

A more detailed summary of the key implications of these expected developments for both Western and Eastern governments, airlines, fuel producers and suppliers is provided in Figure 5.

Key trends to monitor	Key implications along the supply chain		
	Governments	**Airlines**	**Fuel producers & suppliers**
Increasing interest in SAF from governments in the Asia Pacific region, through funding, mandates and roadmaps under development	• Western governments will need to monitor SAF policy developing in APAC to understand implications on feedstock and fuel availability and prices. • Western governments should look to share best practice with Eastern regulators to create consistent mandate monitoring, reporting and verifications processes, as well as strong sustainability standards.	• Western airlines, regardless of their presence in APAC, should monitor developing policy to assess impacts on global SAF supply and demand. • Airlines flying to/from APAC should monitor mandates, taxation, incentives, and more widely passengers' attitudes to sustainability, to work out implications on business models, operations and costs.	• Fuel producers should familiarise themselves with developing policy to understand regulatory impacts on SAF supply and demand globally, as well as funding opportunities, incentives and programmes available to establish production facilities in APAC.
Increasing number of airlines active in the Asia Pacific region committing to SAF use, both on domestic and international flights	• Governments of APAC countries will need to assess the potential price impact of SAF on the growing aviation sector and increasing connectivity. • Governments of APAC countries will need to explore opportunities for SAF demand to be met through domestic production, and how SAF can contribute to national decarbonisation strategies.	• Airlines flying to/from APAC should identify potential SAF procurement routes within the region. • Airlines flying to/from APAC should also understand how SAF use will feature in their decarbonisation strategies, and how to comply with local mandates and regulations practically.	• Local fuel producers or suppliers should proactively seek offtake agreements with airlines. • Fuel producers or suppliers not necessarily active in APAC should look at key demand hubs (e.g. Singapore) to identify potential routes to market entry and risks/ opportunities.
Increasing number of fuel producers, energy companies and oil and gas majors announcing plans to develop SAF production facilities in APAC	• Governments of APAC countries will need to steer production towards desired SAF pathways to be scaled up (e.g. HEFA/PtL) based on local resources availability and costs. • European governments will need to monitor emerging supply hubs to identify potential trade strategies and opportunities.	• Airlines flying to/from APAC should monitor technology developments and identify potential SAF procurement routes within the region. Moving early will be essential to secure offtake agreements. • Airlines who have signed offtake agreements or invested in SAF plants developing elsewhere should understand potential fuel supply risks that could affect SAF production and delivery in line with expected timelines.	• Local fuel producers or suppliers should proactively seek offtake agreements with airlines. • Fuel producers or suppliers not necessarily active in APAC should look at competitor activity to identify opportunities (including partnerships and potential routes to market entry) as well as threats (e.g. competition for customers).
Increasing prioritisation of SAF feedstock available in Asia Pacific for local fuel production	• APAC governments will need to clarify the role of bioresources and waste across the economy, to determine whether and how these should be used for SAF. • Governments of APAC countries will also need to identify where such resources are currently exported, to put in place new trade strategies that allow the development of the local SAF industry. European governments will need to factor in potential shortfalls in mandates and supply chain bottlenecks as greater volumes of feedstock are used abroad, and look at alternative SAF pathways.	• Airlines flying to/from APAC should identify sustainability risks associated with potential SAF feedstock currently used in Asia, and assess the implications of these on compliance with international schemes (e.g. CORSIA) and overall reputation. • Airlines who have signed offtake agreements or invested in SAF plants developing elsewhere should understand potential feedstock supply risks that could affect SAF production and delivery in line with expected timelines.	• APAC fuel producers or suppliers should proactively explore commercial arrangements to get hold of local feedstock needed to scale up SAF pathways, including through engagement with local communities, regulators and other sectors. • European fuel producers or suppliers should identify potential supply chain bottlenecks or feedstock shortages that could affect volumes and/or costs, and look to secure long-term agreements to mitigate these.

Key trends to monitor	Key implications along the supply chain		
	Governments	**Airlines**	**Fuel producers & suppliers**
Increasing development and commercialisation of indigenous SAF production technology in Asia Pacific (e.g. electrolysers for PtL)	• APAC governments will need to identify opportunities to establish new supply chains that could support SAF production, as well as other technologies and sectors. Incentives could be designed accordingly. • Western governments will need to monitor technology developments and their costs, both to identify opportunities (e.g. faster price reductions) and to assess threats to the growth of existing manufacturing capabilities or increased technology and intellectual property dependencies.	• Airlines flying to/from APAC should assess price implications of particular technology pathways scaling up within the whole region to determine ticket price sensitivity. • Airlines should also explore potential partnership with local technology developers to accelerate the commercialisation of these and the growth of economies of scale.	• APAC fuel producers should consider adopting SAF production technologies more readily available within the region to increase the potential for cost advantages. • Fuel producers outside APAC should consider licencing SAF production technology developed elsewhere. • Both APAC and other fuel producers should capitalise on the availability of incentives and subsidies for the development of certain SAF (and related) technologies.

Figure 5 – Key SAF trends to monitor in Asia Pacific and implications across the supply chain for both Western and Eastern governments, airlines and fuel producers and suppliers.

For each of the players active along the SAF supply chain multiple opportunities and risks will arise. Eastern governments and industry players will need to consider any lessons learned from existing policy and commercial activity in Europe and US to speed up the local deployment of SAF as quickly as possible. On the other side, Western governments, oil and gas players and airlines will have to assess the potential for policy or trade collaborations (between governments), as well as partnerships and market entry opportunities (for airlines and fuel producers/suppliers) to foster accelerated SAF uptake and cost reductions and benefit from global market developments.

If these opportunities are not managed well, inconsistent policies, sustainability risks and supply and demand mismatches could lead to a drastic re-shaping of the global SAF feedstocks and fuel trades, with potential impacts on technology deployment in the near-to-medium term. These may be particularly felt in those markets where SAF activity has concentrated to date, predominantly Europe. Any feedstock or SAF shortages that may arise in the West as a result of potential disruptions could eventually open the door to other less developed SAF markets too, such as the Middle East and South America, to be explored further in a future paper.

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