RystadEnergy

Sourcing, the immediate decarbonization lever for aviation

Whitepaper

An analysis of fuel sourcing and its impact on lifecycle emissions

Emissions Solution
22 September 2026

Sourcing choices can cut jet fuel emissions as much as the EU’s 2030 SAF mandate

The aviation sector emits around 1.1 gigatonnes of CO_2 per year from the combustion of jet fuel, and demand is still rising. The designated decarbonization pathway for the industry – laid out by coalitions of industry partners, governments and regulators – is increased use of sustainable aviation fuel (SAF). However, the available volumes of SAF could be limited to meet surging global demand. As a result, additional approaches are set to enter the decarbonization toolbox for the aviation industry, including carbon credits and potentially verified low-intensity fossil jet fuel.

The European Union’s target to blend 6% SAF into jet fuel by 2030 would cut the average lifecycle emission intensity of jet fuel by around 4% – corresponding to a reduction to 492 kg CO_2e per barrel of oil equivalent (boe) for the average lifecycle of jet fuel, from 513 kg currently.

These average numbers hide significant variations in emission intensity between different jet fuel value chains, however. In some cases, the gap in emission intensity between jet fuel sourced from different routes is even larger than the reduction expected from the EU’s 2030 blending requirement. Our analysis of available jet fuel supply sources at various airports shows differences in lifecycle emission intensity of 26–50 kg CO_2e per boe – which means that a switch in fuel source can already today deliver at least the same reduction as the EU 2030 blending requirement. SAF also carries a 2x cost premium compared to conventional jet fuel. Jet fuel purchasers can drive significant lifecycle emissions reductions through data-informed procurement, and do so at a lower cost than alternative routes to the same cut.

To arrive at these numbers, we have estimated every refinery's crude oil intake and coupled the emission intensity of the upstream feedstock with those stemming from jet fuel-specific refining operations. This highlights the impact jet fuel sourcing can have on lifecycle emissions intensity.

The main reason for the variation in jet fuel emission intensity between different supply chains is the sourcing of the crude oil used. The world’s four largest crude oil grades by volume range from less than 10 kg to nearly 60 kg CO_2e per boe in emission intensity, while the gap between the global 5^{th} and 95^{th} percentile is 66 kg CO_2e per boe. These variations are largely independent of how the refineries are configured.

Refinery selection also has significant impact on lifecycle emissions, as jet fuel is the second most energy-intensive product after gasoline. Our analysis of refineries shows that jet fuel-specific refining intensity ranges from 10 kg to 80 kg CO_2e/boe at different refineries, with the gap between the 5^{th} and 95^{th} percentile at 41 kg CO_2e/boe.

Cutting emissions through fuel-source switching will not change SAF's long-term decarbonization role. But while SAF supply could be constrained, it is a saving that is available immediately and at a scale with potential to be implemented at all airports globally. In the long-run, fuel-source switching could drive a price signal that rewards lower-emitting refineries and producers and therefore change industry practice.

> A switch in jet fuel source can already today deliver at least the same reduction as the EU 2030 blending requirement

Patrick King
Head of Emissions Research, Rystad Energy

Source: Rystad Energy research and analysis

Blending requirements come at the same time as increased scrutiny over product intensity

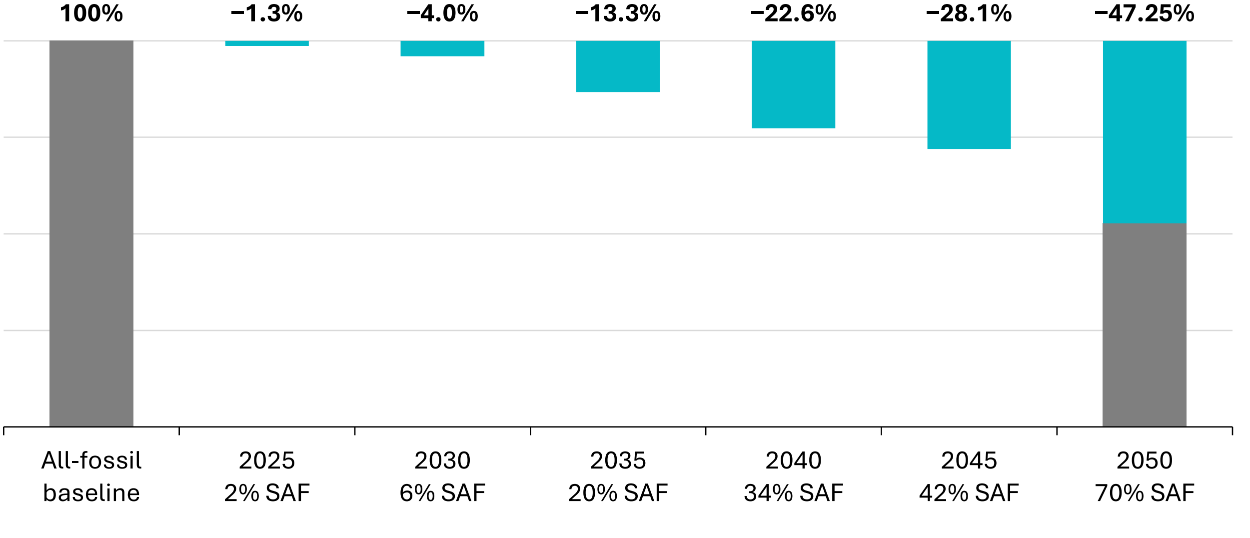
Conventional fossil jet fuel has been the standard over the history of aviation, powering almost all flights globally every day. Jet fuel produces 1.1 gigatonnes of CO_2 every year, or around 5% of global end-use emissions from oil and gas. Aviation is one of the hardest sectors to decarbonize because it has no viable large-scale electrification pathway and still depends on energy-dense liquid fuels. Jet fuel demand is expected to rise from about 7.5 million barrels per day (bpd) in 2025 to more than 10 million bpd by 2050 – which means emissions will keep rising unless alternative fuels are introduced at scale.

Sustainable aviation fuel (SAF) is expected to do most of the heavy lifting in decarbonizing the industry. In Rystad Energy's base case, SAF reaches around 12% of the global aviation fuel mix by 2040, and the International Air Transport Association (IATA)'s framework assigns around 65% of required aviation emissions reductions to SAF. Linked to this decarbonization pathway, a number of blending requirements for SAF have emerged at international, regional and national levels. These include the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) mandate from the International Civil Aviation Organization (ICAO), which covers use of both carbon credits and SAF, as well as the EU's blending mandate calling for 2% SAF by 2025, rising to 20% by 2035 and up to 70% by 2050.

The CORSIA framework has detailed the lifecycle intensity of SAF fuel sources and that of combustion of conventional fossil jet fuel. Combined with the blending requirement from the EU, this can be used to estimate potential emissions savings over the lifecycle of European jet fuel as blending rates rise. A 2% blending rate gives an estimated emissions saving of 1.3%, while 6% blending in 2030 can give a 4% saving – and the 70% blending mandate in 2050 can give an emission reduction of 47.3%.

This shows that significant emissions savings are feasible with the use of SAF. One key risk is the future availability of SAF and whether it will be able match demand. Rystad Energy's risked global SAF capacity reaches around 570,000 bpd by 2030, above forecast demand of around 330,000 bpd – but low utilization rates, project-execution risks and feedstock constraints mean that the apparent capacity surplus does not remove supply risk.

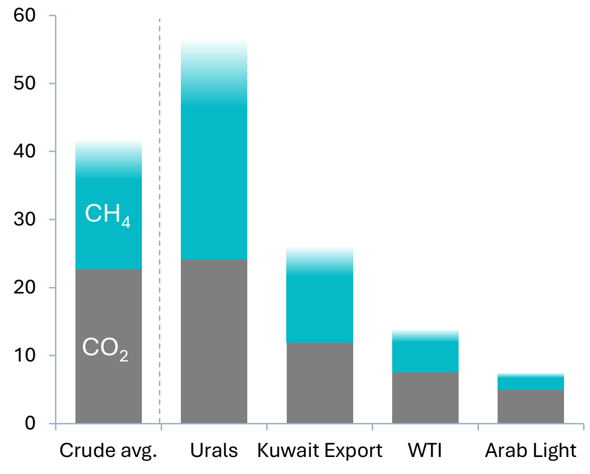
Lifecycle emissions savings from the ReFuelEU SAF blending mandate, 2025–2050[1)]
Lifecycle carbon intensity of jet fuel supplied, % of all-fossil jet fuel (= 100%); each year measured vs. baseline



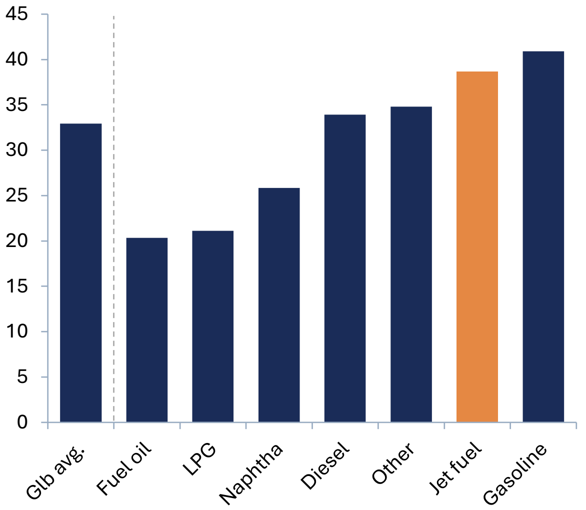
1) GHG reductions under ReFuelEU are assumed to be 65% for bio-SAF and 70% for e-SAF
Source: Rystad Energy research and analysis; Rystad Energy Emissions Solution; ICAO CORSIA; Regulation (EU) 2023/2405

Emissions vary substantially in jet fuel value chain elements

Upstream crude production emissions intensity
kg CO_2e per boe



Refining emissions intensity
kg CO_2e per boe



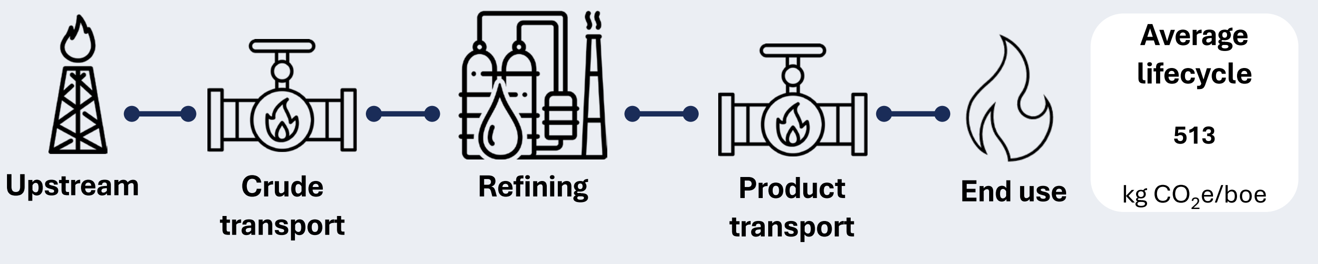
The average lifecycle emissions of jet fuel are currently around 513 kg CO_2 per boe. The EU's blending mandate of 6% SAF by 2030 has potential to reduce lifecycle emissions intensity of jet fuel by 4%. For fossil jet fuel, this would cut the lifecycle intensity by 21 kg to 492 kg CO_2e per boe on average. With SAF supply constrained, there is scope to look for verified fossil jet fuel sources that can provide the same reduction in lifecycle emissions as use of SAF.

While emissions from end-use combustion are fixed, several other points in the jet fuel value chain can vary in emission intensity, including crude sourcing, transportation and refining. Of these, upstream sourcing and refining show the largest variations. A conscious choice at either of these two stages - informed by credible analysis of refinery and feedstock emissions - could provide a similar 4% cut in lifecycle emissions.

Upstream: The upstream intensity in the top left chart shows average upstream emission intensity for the world's top four crude grades by volume, as well as the global average, which sits at around 40 kg CO_2e per boe. The intensity of the four largest crudes ranges from nearly 60 kg to less than 10 kg. The variation can be even larger if the selection is expanded to more crude types or to individual companies, geographies or assets.

Downstream: This is also the case for downstream assets, with significant variation in emission intensity between different products from the same refinery, as well as between refineries, operators and complexities globally. As shown in left chart, jet fuel is the second most emission-intensive product, behind gasoline, with its average refining operations just below 40 kg CO_2e per boe.

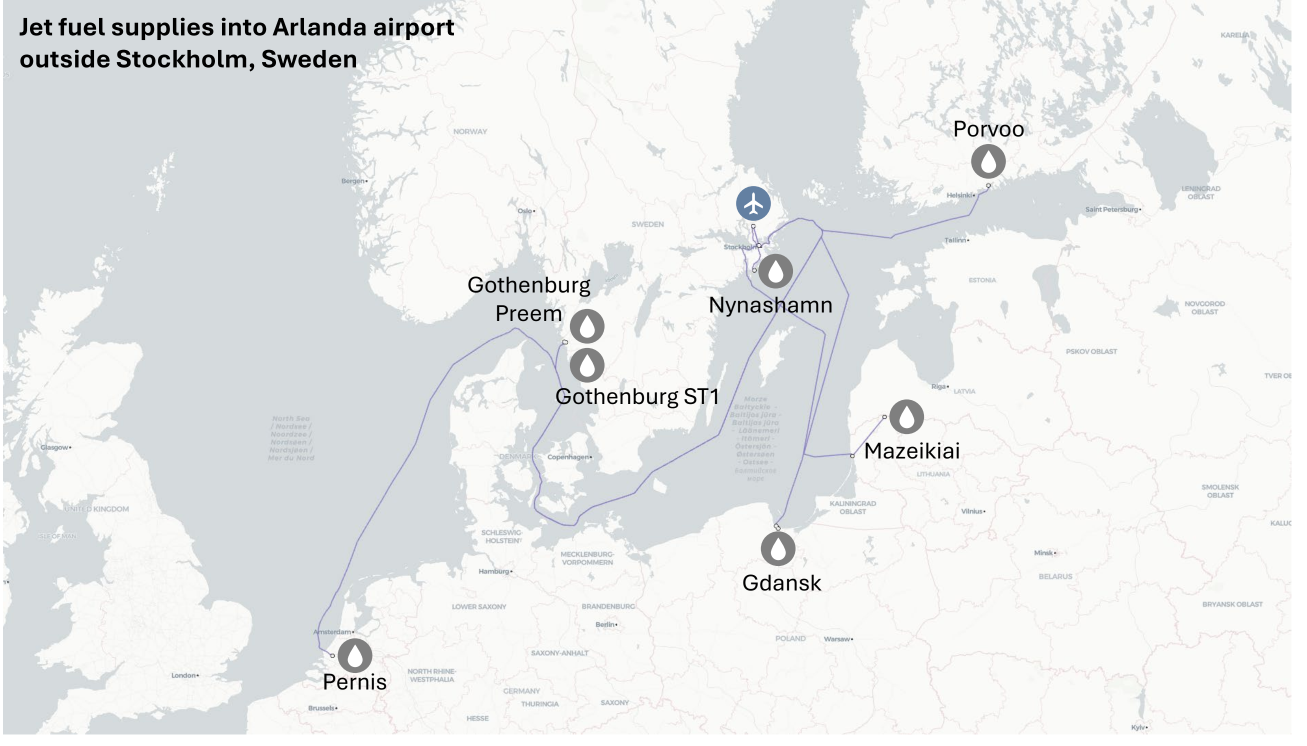
Jet fuel lifecycle emission stages



1) Data provided is for 2024
Source: Rystad Energy research and analysis; Rystad Energy Emissions Solution

Airport case study: Variation of over 30 kg CO_2e per barrel for Arlanda fuel supplies

Jet fuel supplies into Arlanda airport outside Stockholm, Sweden



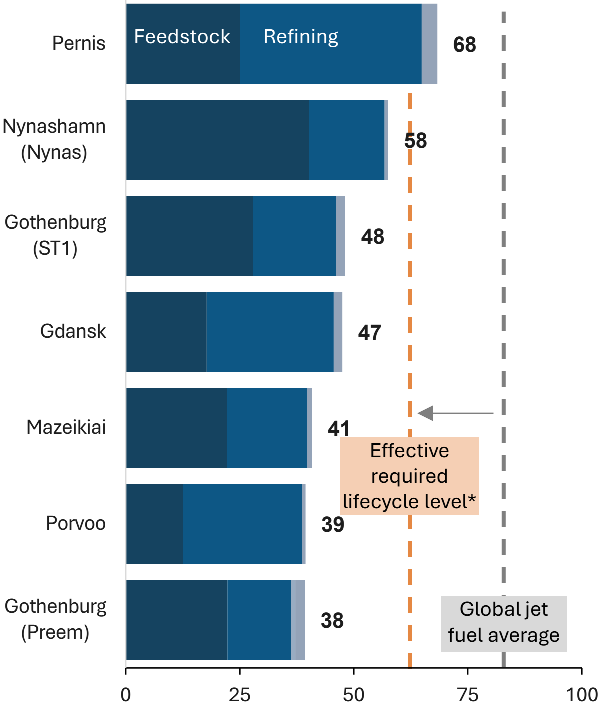
To show the variation in emissions intensities of different sources of jet fuel, Rystad Energy has analyzed jet fuel sourcing into Stockholm's Arlanda Airport from surrounding local refineries. Rystad Energy emissions data is visualized above in the Kinertic platform.

Supplies of jet fuel have been modeled from seven European refineries: Pernis, Gdansk, Nynashamn, Mazeikiai, Gothenburg ST1, Porvoo and Gothenburg Preem. All of these have a strong likelihood of supplying Arlanda with jet fuel.

While these seven refineries all produce the "same" molecules chemically speaking, there are significant differences in the value chains, from the upstream wells providing the crude oil through to the final refined jet fuel. All seven refineries can supply kerosene to Arlanda at a value chain intensity (lifecycle emissions minus end use) below the global average of 83 kg CO_2e/boe.

Our analysis finds six of the refineries – all except Pernis – deliver jet fuel with an emission intensity that is below the effective level of the EU's 2030 SAF blending requirement

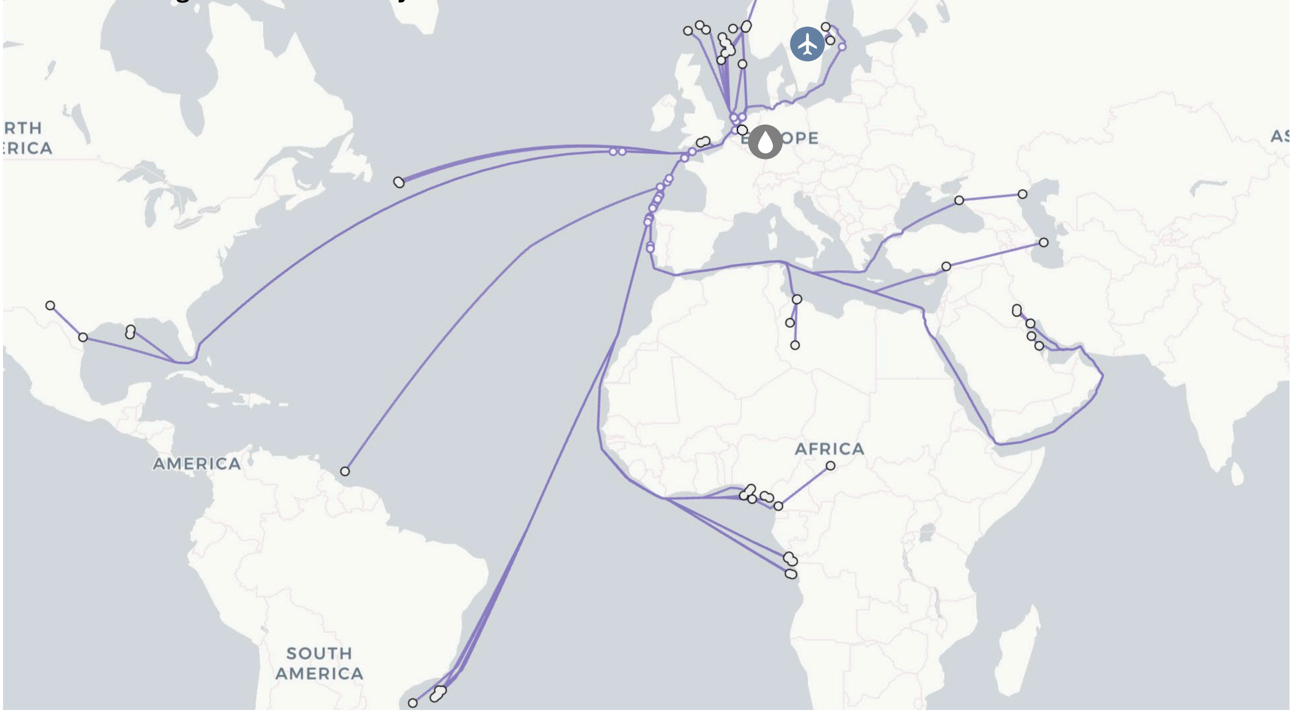
Jet fuel supply routes into Stockholm Arlanda (ARN)
Value chain carbon intensity (excl. end use), kg CO_2e/boe



*EU 2030 effective required lifecycle level is calculated based on average global carbon intensity and expected carbon intensity of EU SAF mandate
Source: Rystad Energy research and analysis; Rystad Energy Emissions Solution; Kinertic

Crude sourcing has significant impact on lifecycle emissions

Crude sourcing for Pernis refinery in Rotterdam



As seen on the previous page, the jet fuel lifecycle from well to refining to transportation varies for different refineries. For Arlanda's supply of jet fuel, value-chain emissions range from 38 kg to more than 68 kg CO_2e per boe, with end-use combustion providing a further ~430 kg CO_2e. For the average global barrel of jet fuel, end-use combustion makes up 81% of lifecycle emissions, upstream extraction 9.5%, refining 7.7% and transport the last 2%.

The two stages a refiner can influence, and by extension the purchaser, are upstream feedstock emissions and the refining process emissions themselves. Upstream is both the larger and the wider-ranging of the two: between the 5th and 95th percentiles of global upstream throughput, intensity varies by 66 kg CO_2e per boe. The corresponding figure for the refining stage is 41 kg. Feedstock choice is the bigger lever on the finished barrel, with the emission intensity of the feedstock largely independent of how the refinery is configured.

The most important aspect of accurately estimating the lifecycle emissions of any fossil fuel is knowing the composition of the individual feedstock. This allows the emissions intensity of the feedstock to be accurately evaluated, both from a production and a transport perspective. In addition, the types of crude slates used by a refinery directly affects the processes the refinery must use to produce a given refined product – which in turn impacts the ultimate emissions of the jet fuel.

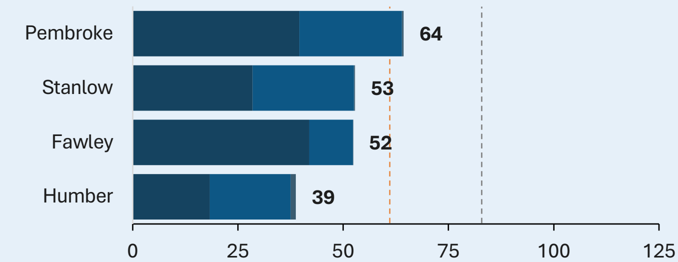
The map above shows the estimated crude intake of Shell's Pernis Refinery, a large complex deep conversion refinery in the Netherlands. The refinery pulls in crudes slates from a number of sources, from WTI in the US to North Sea blends and Persian Gulf volumes. All of these influence the emissions makeup of the supply and ultimately the lifecycle emissions of a given barrel of product.

Rystad Energy's product intensity estimates build on these crude flows, taking into account the various feedstock sources with different upstream emission intensities as well as the estimated crude intake for each refinery, creating product intensity estimations from the bottom up. The above image shows the crude sourcing for Pernis in 2024 – and the same exercise is done for every refinery globally, with the results feeding into our emissions databases for upstream and refineries.

Source: Rystad Energy research and analysis; Rystad Energy Emissions Solution; Kinertic

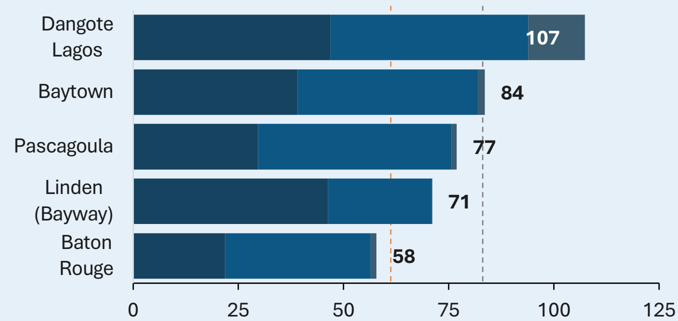
LHR, JFK and LAX also show significant emissions differentiation based on crude sourcing

Jet fuel supply routes into London Heathrow (LHR) – lifecycle carbon intensity, kg CO_2e/boe



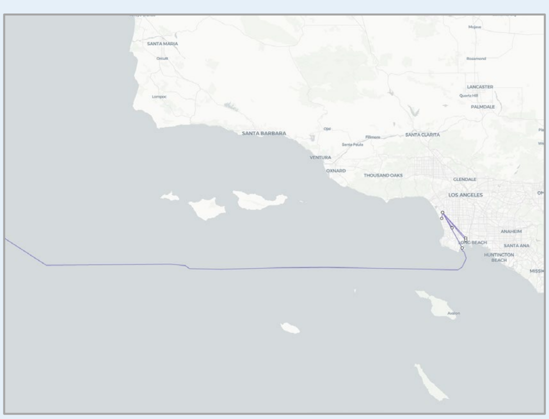
All of the UK's four major refineries with the potential to supply jet fuel fall below the global average. Three of the four have a low enough lifecycle intensity to exceed the decline needed to match a 6% SAF blending mandate.

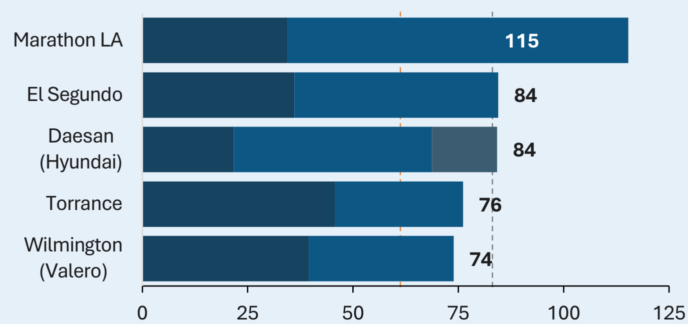
Jet fuel supply routes into New York Kennedy (JFK) – lifecycle carbon intensity, kg CO_2e/boe



Of the selected example refineries to supply jet fuel to JFK, almost all sit below the global average.

Jet fuel supply routes into Los Angeles (LAX) – lifecycle carbon intensity, kg CO_2e/boe





Supplies into LAX have significantly higher emissions intensity than the other refineries researched.

1) Feedstock supply chains are examples based on proximity and likely transport routes
Source: Rystad Energy research and analysis; Rystad Energy Emissions Solution; Kinertic

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