Can Sustainable Aviation Fuel Meet Future Demand?

A note about this e-book


Rajvi Megha
Research Associate


Runeel Daliah
Principal Analyst

This e-book is an abridged version of our popular webinar “Can Sustainable Aviation Fuel Meet Future Demand?”

For the full webinar, which provides more research and context, please visit our website here.

Sustainable Aviation Fuel

Prepare for accelerating SAF* demand, but expect multiple technologies and feedstocks to share the market rather than one winner.

PRODUCT DESIGN & INNOVATION

Prioritize innovations that expand usable feedstocks or improve proven conversion technologies instead of adding entirely new pathways.

BRAND

Use credible SAF commitments to support decarbonization goals without overpromising technologies that have yet to demonstrate commercial scale.

SUPPLY CHAIN & OPERATIONS

Secure low-carbon feedstocks early, as growing mandates will intensify global competition for waste oils, ethanol, biomass, and green hydrogen.

GROWTH POTENTIAL

Capture SAF growth by matching technology investments to regional feedstock advantages, regulation, infrastructure, and achievable production economics.

*Sustainable Aviation Fuel

Key takeaways

01

Expand HEFA* beyond waste oils to meet SAF mandates.

HEFA is commercially mature, but waste-oil supply is insufficient to meet future SAF mandates; clients should prioritize scalable alternative feedstocks and conversion pathways.

02

Focus on scaling technologies rather than developing new ones.

Novel technology platforms for SAF are available but are not yet scaled; development efforts should focus on improving these technologies rather than focusing on R&D for new conversion platforms.

03

Prioritize bio-SAF over e-SAF.

Persistently high renewable electricity costs lead to expensive green hydrogen; investment should focus on overcoming bottlenecks in bio-SAF technologies rather than e-SAF.

*Hydroprocessed Esters and Fatty Acids

SAF demand is rising faster than the market can scale

Key takeaway: *No single SAF pathway can meet future demand. Companies need a portfolio strategy built around feedstock access, technology maturity, and economics.*

Sustainable aviation fuel demand could approach 40 million tonnes by 2050 as mandates expand and existing requirements strengthen. Yet global production reached only 1.9 million tonnes in 2025.

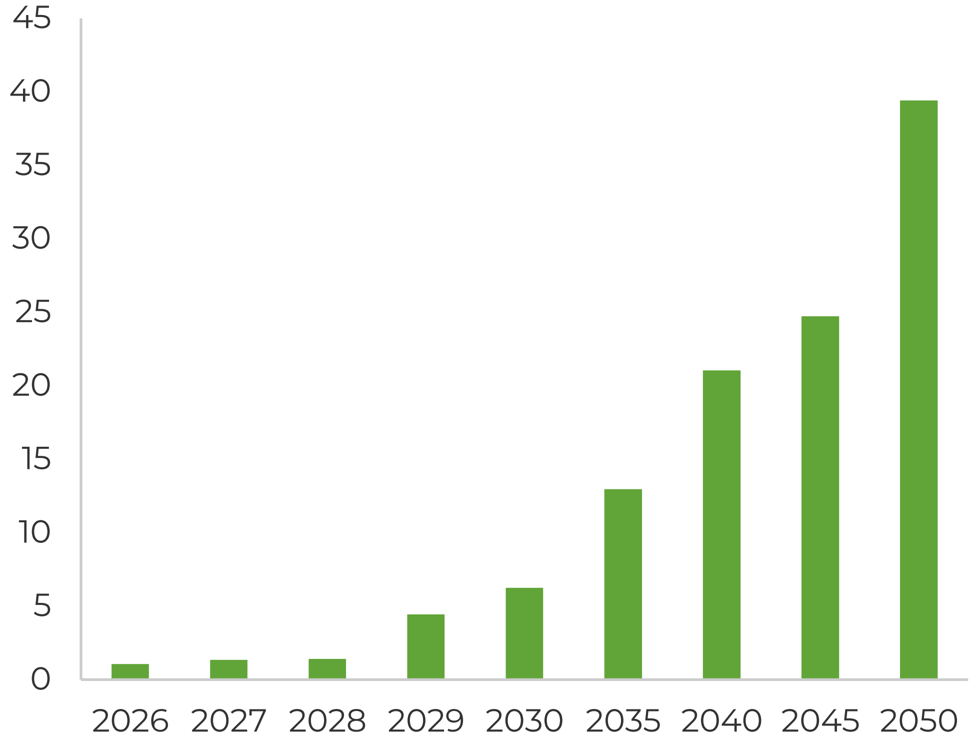
Closing that gap will require more than adding capacity.

- HEFA is commercially mature but constrained by waste-oil supply.
- Biomass pathways offer abundant feedstocks but still face scale-up challenges.
- Ethanol-to-jet could become highly competitive where regulations allow suitable feedstocks.
- E-SAF pathways broaden feedstock options but remain prohibitively expensive.

For executives, the priority should be maximizing proven pathways today while positioning for the technologies and feedstocks required after 2030.

Projected SAF Demand Based on Global Mandates

SAF demand (Mtonne)



Mandates are creating a demand challenge

Key takeaway: *Policy is creating a rapidly expanding SAF market, but announced demand is moving well ahead of available production.*

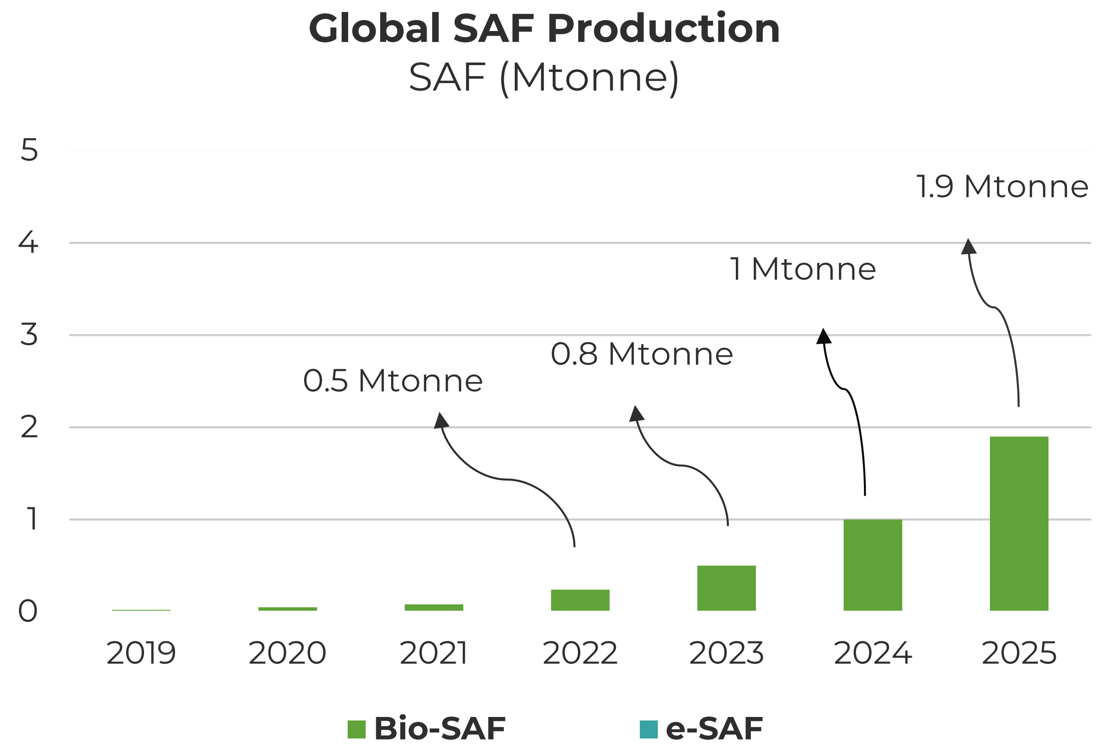
SAF adoption is increasingly mandate-driven. The EU and U.K. already have active requirements, while countries across Asia are considering mandates or targets of their own.

The result is a significant increase in demand:

- Global SAF demand is approximately 1.2 million tonnes in 2026.
- Demand could exceed 6 million tonnes by 2030.
- By 2050, mandates under consideration could push demand toward 40 million tonnes.

Supply has grown, but from a very small base. Production increased from roughly 0.5 million tonnes in 2022 to 1.9 million tonnes in 2025.

The strategic question is no longer whether SAF demand will emerge. It is which technologies can scale quickly enough to serve it.



The ideal SAF pathway does not exist

***Key takeaway:** Executives should assess SAF technologies against four factors rather than assuming the most mature pathway will automatically win.*

Five major pathways are competing to supply the future SAF market: bio-oil, biomass, ethanol, methanol, and CO_2-to-SAF.

Lux evaluates them against four requirements:

- **Abundant feedstock:** Supply must support a commodity-scale aviation market.
- **Sustainable feedstock:** Inputs must deliver meaningful carbon reductions.
- **Scalable technology:** Production must ultimately approach conventional refinery economics and scale.
- **Experienced developers:** Multibillion-dollar projects require credible technology providers and financing.

No pathway currently performs strongly across all four dimensions.

This creates an important portfolio decision: Companies must balance what can be deployed now against what could become scalable later.

WHAT MAKES AN IDEAL SAF TECHNOLOGY?

+ Abundant feedstock	No feedstock limitations
+ Sustainable feedstock	SAF should have a low carbon intensity
+ Scalable technology	Fuel is a commodity market
+ Experienced developers	Multi-billion-dollar projects

HEFA leads today, but feedstock will define its ceiling

Key takeaway: *Maximize HEFA deployment while securing alternative feedstocks before competition intensifies.*

Bio-oil-to-SAF through HEFA is the market's most mature pathway. Its refining process resembles conventional fuel production, and experienced technology providers already support commercial-scale projects.

Its weakness is not technology. It is feedstock.

Waste oils such as used cooking oil and animal fats are low carbon but inherently limited and geographically distributed. As more countries introduce mandates, competition for the same supply will increase.

Companies should:

- Secure long-term waste-oil agreements early.
- Explore nonfood energy crops such as camelina.
- Monitor technologies producing HEFA-compatible oils from alternative inputs.

Innovations from companies such as Cemvita and partnerships like Bayer-BP's newgold could broaden the feedstock base, but large-scale impact remains several years away.

BIO-OIL TO SAF		
–	**Limited feedstock**	Waste oil is limited and distributed in supply
+	**Sustainable feedstock**	SAF should have a low carbon intensity
+	**Scalable technology**	Fuel is a commodity market
+	**Experienced developers**	Multi-billion-dollar projects

Abundant biomass still needs a scalable conversion route

Key takeaway: *Focus on improving existing biomass conversion technologies rather than waiting for entirely new platforms.*

Agricultural, forestry, and other biomass residues offer something waste oils cannot: globally abundant low-carbon feedstock.

The challenge lies in converting that feedstock reliably and economically.

Gasification followed by Fischer-Tropsch synthesis is technically established but has yet to demonstrate successful commercial biomass-to-jet production. Tar formation can contaminate syngas, damage catalysts, and increase maintenance requirements.

Pyrolysis is even earlier stage. Its bio-oil requires significant upgrading and hydrogen, and the pathway still lacks ASTM International* approval for SAF.

Startups such as Haffner Energy are working to solve these bottlenecks, but executives should treat biomass-to-SAF as a strategic scale-up opportunity rather than a near-term replacement for HEFA.

BIOMASS TO SAF		
+	**Abundant feedstock**	Forestry & agricultural feedstock is widely available globally
+	**Sustainable feedstock**	Biomass has a low carbon intensity
–	**Developing technology**	**Gasification technology for fuels remains immature; challenges around tar formation**
–	**Emerging developers**	**Crowded startup landscape and few corporations, but no leaders yet**

* American Society for Testing and Materials

Ethanol could become the strongest alternative to HEFA

Key takeaway: *Ethanol-to-jet becomes particularly attractive where existing ethanol infrastructure and favorable feedstock rules align.*

Ethanol-to-jet has an important advantage: Its conversion technology is backed by experienced licensors and can leverage established ethanol supply chains.

The major constraint is regulatory.

The EU and U.K. restrict first-generation ethanol derived from crops, leaving second-generation cellulosic ethanol as the primary eligible option. That technology remains difficult and expensive to scale.

Outside those markets, the opportunity could look very different.

Where first-generation ethanol is permitted, abundant existing production could accelerate deployment. Brazilian sugarcane is particularly attractive due to its comparatively lower carbon intensity.

For executives evaluating alternatives to HEFA, ethanol-to-jet should be a priority, especially where regulation and regional feedstock availability create favorable economics.

ETHANOL TO SAF		
+ –	**Abundant feedstock**	1G ethanol is widely available but disallowed in the EU & U.K.; 2G ethanol is highly limited
+ –	**Sustainable feedstock**	2G ethanol from biomass is sustainable; only 1G ethanol from sugarcane has low carbon intensity
+	**Scalable technology**	ETJ is at demonstration scale; scale is defined by feedstock capacity
+	**Experienced developers**	Multiple large corporations in the market (Honeywell UOP, Axens, etc.)

Methanol-to-SAF is the stronger near-term e-SAF pathway

Key takeaway: *Methanol-to-SAF combines mature technology developers with lower projected costs than CO_2-to-SAF, but feedstock availability remains constrained.*

Methanol-to-SAF converts low-carbon methanol into jet fuel through catalytic conversion, oligomerization, and hydrogenation. The pathway received ASTM approval in 2026 and benefits from participation by experienced technology providers, including Honeywell and Topsoe. Its primary constraint is feedstock.

- Biomethanol is limited by distributed biogas supply.
- e-methanol remains scarce and expensive.
- Green hydrogen costs continue to drive unfavorable economics.

Despite these barriers, Lux's analysis indicates methanol-to-SAF offers a lower-cost e-SAF route than CO_2-to-SAF.

For companies required to meet e-SAF mandates, methanol-to-SAF should be the priority. The strongest opportunities may come from sourcing low-carbon methanol from regions with cheaper renewable electricity and importing it into demand centers.

METHANOL TO SAF		
−	**Limited feedstock**	Biomethanol is constrained by availability of biogas; e-methanol remains scarce
+	**Sustainable feedstock**	Both biomethanol and e-methanol have low carbon intensity
−	**Developing technology**	MTJ technology remains at the pilot scale
+	**Experienced developers**	Multiple large corporations in the market (Honeywell UOP, Topsoe, ExxonMobil)

CO_2-to-SAF offers scale potential, but economics remain a major barrier

Key takeaway: *CO_2-to-SAF could unlock abundant low-carbon feedstocks, but technology scale-up and green hydrogen costs limit near-term deployment.*

CO_2-to-SAF converts captured or biogenic CO_2 and green hydrogen into jet fuel, typically through reverse water-gas shift and Fischer-Tropsch synthesis. The pathway benefits from theoretically abundant feedstocks and experienced technology developers, but commercial maturity remains limited.

Key challenges include:

- Small-scale Fischer-Tropsch systems still need to prove reliable performance and economics.
- Green hydrogen remains expensive and has an outsized impact on production cost.
- Modular systems must demonstrate they can scale without sacrificing efficiency.

Innovators such as OXCCU and Twelve are working to simplify the process and reduce capital requirements. However, both remain at demonstration scale. CO_2-to-SAF should be treated as a longer-term strategic option, especially where e-SAF mandates justify higher costs.

CO_2 TO SAF		
+	**Abundant feedstock**	CO_2 from ambient air and green hydrogen are (theoretically) abundant; biogenic CO_2 less so
+	**Sustainable feedstock**	(Ambient or biogenic) CO_2 and green hydrogen have a low carbon intensity
–	**Developing technology**	Small-scale FT for SAF is at demonstration scale
+	**Experienced developers**	Multiple large corporations in the market (Sasol, Johnson Matthey, BP, Shell)

Cost will determine which pathways actually scale

***Key takeaway:** Even under optimized assumptions, every SAF pathway remains more expensive than conventional jet fuel.*

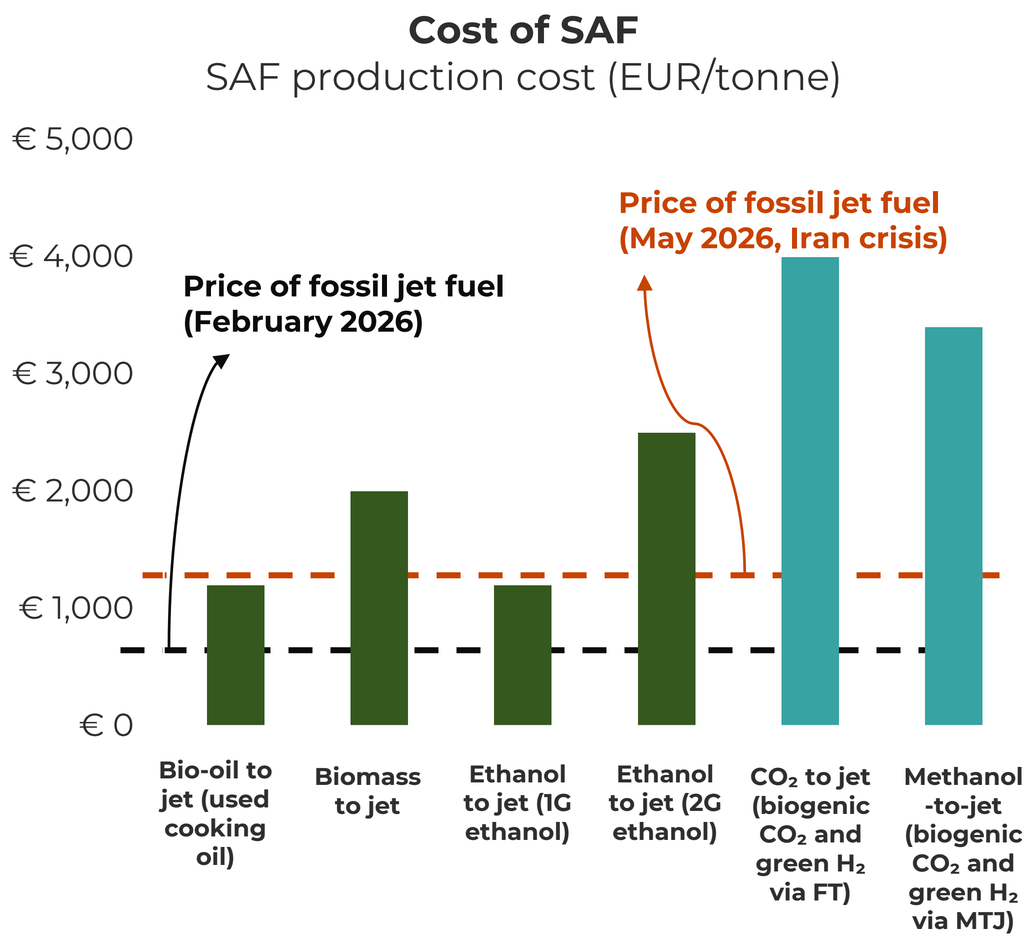
Lux's analysis assumes mature, optimized production at approximately 1 million tonnes per year. Even under those conditions, significant premiums remain.

Approximate production costs include:

- Bio-oil-to-jet: €1,200 per tonne
- 1G ethanol-to-jet: €1,200 per tonne
- Biomass-to-jet: €2,000 per tonne
- 2G ethanol-to-jet: €2,500 per tonne
- Methanol-to-jet: €3,400 per tonne
- CO_2-to-jet: €4,000 per tonne

By comparison, conventional jet fuel was approximately €700 per tonne in February 2026.

The economics strongly favor bio-SAF, while e-SAF will continue to depend on mandates and financing support.



WHERE TO PRIORITIZE

Build the SAF portfolio in three steps

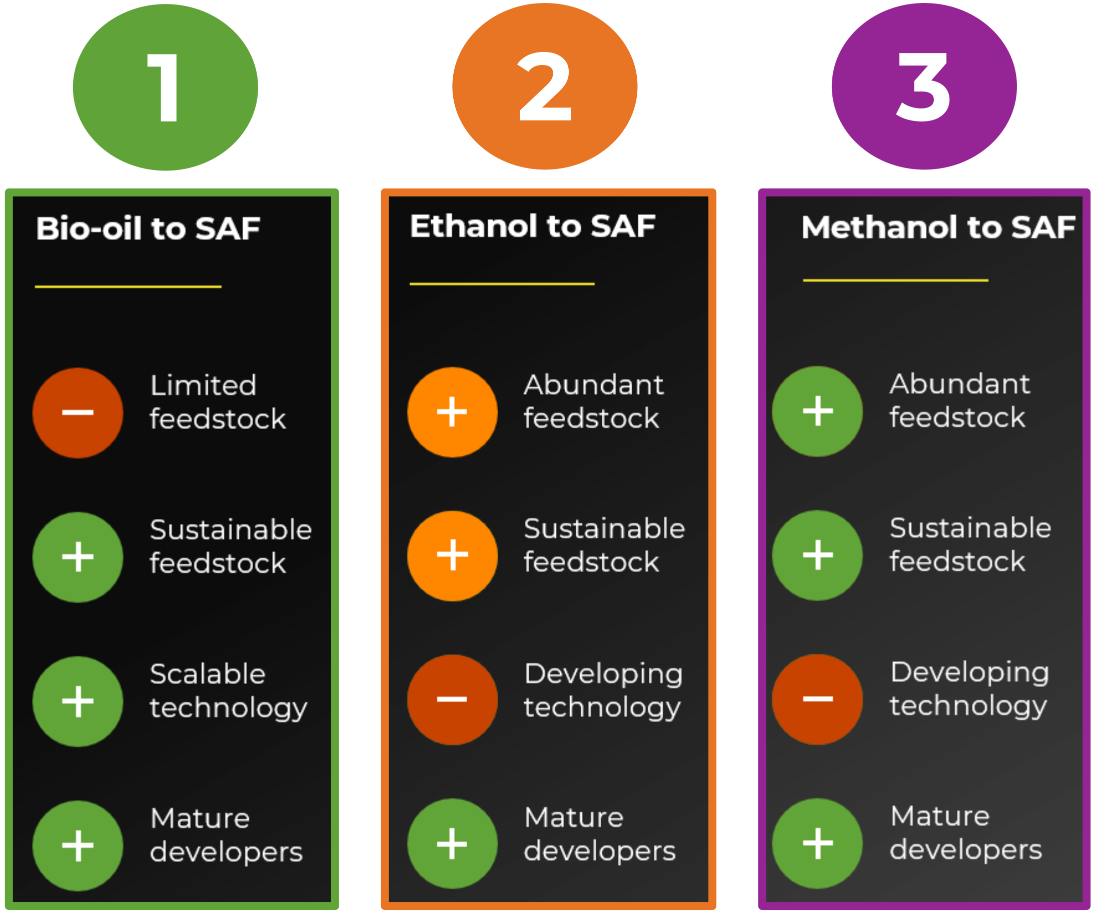
***Key takeaway:** Prioritize commercial readiness first, scalable feedstocks second, and e-SAF only where policy requires it.*

Executives should sequence SAF investment rather than betting equally across every pathway.

1. **Maximize bio-oil-to-SAF.** Secure waste-oil supply and expand HEFA-compatible feedstocks through energy crops and emerging bio-oil technologies.
2. **Scale ethanol-to-jet.** Where regulation allows, use established ethanol infrastructure to create the next major source of SAF capacity.
3. **Choose methanol-to-jet for e-SAF requirements.** Its economics currently compare more favorably with CO_2-to-SAF, although affordable green hydrogen remains essential.

Regional strategies should reflect local advantages. HEFA is relevant across the U.S., Europe, and Asia, while ethanol becomes particularly attractive in regions with established production and permissive regulations.

The winning strategy will be regional, feedstock-led, and economically disciplined.



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