Lux Research

Can Sustainable Aviation Fuel Meet Future Demand?

© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

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.

© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

Sustainable Aviation Fuel (SAF)

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.

© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

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.

© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

*HEFA, hydrotreated esters and fatty acids

SAF demand is rising faster than the market can scale

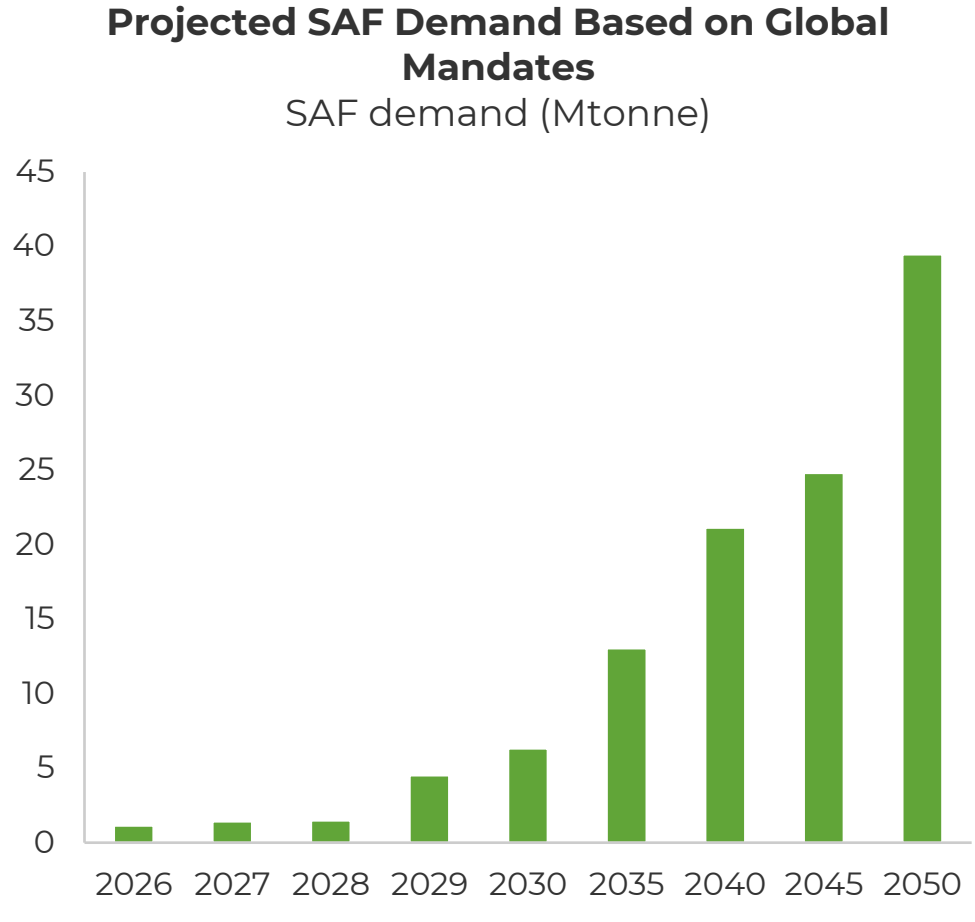
Key takeaway: *No single SAF pathway can meet future demand. Companies need a portfolio strategy built around feedstock access, technology maturity, and economics.*

SAF demand could approach 40 million tonne by 2050 as mandates expand and existing requirements strengthen. Yet global production reached only 1.9 million tonne 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.



© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

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.*

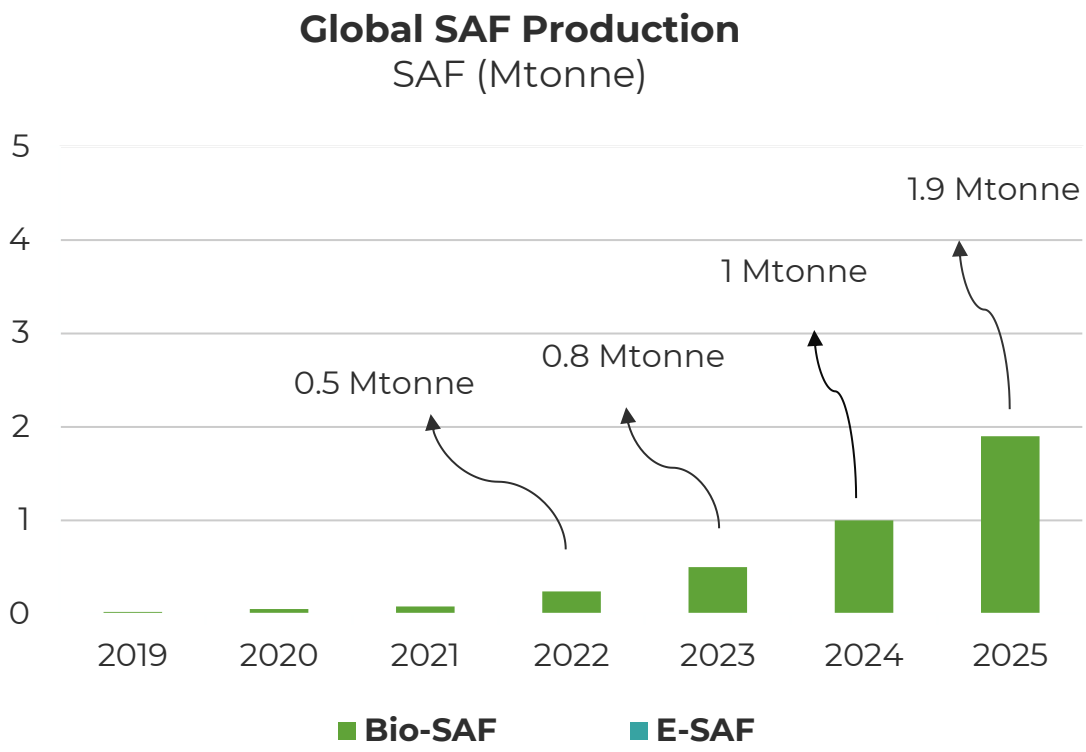
SAF adoption is increasingly mandate driven. The EU and U.K. already have active requirements, while countries across Asia are considering mandates or targets of their own.

The result is a significant increase in demand:

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

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

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



© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

The ideal SAF pathway does not exist

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

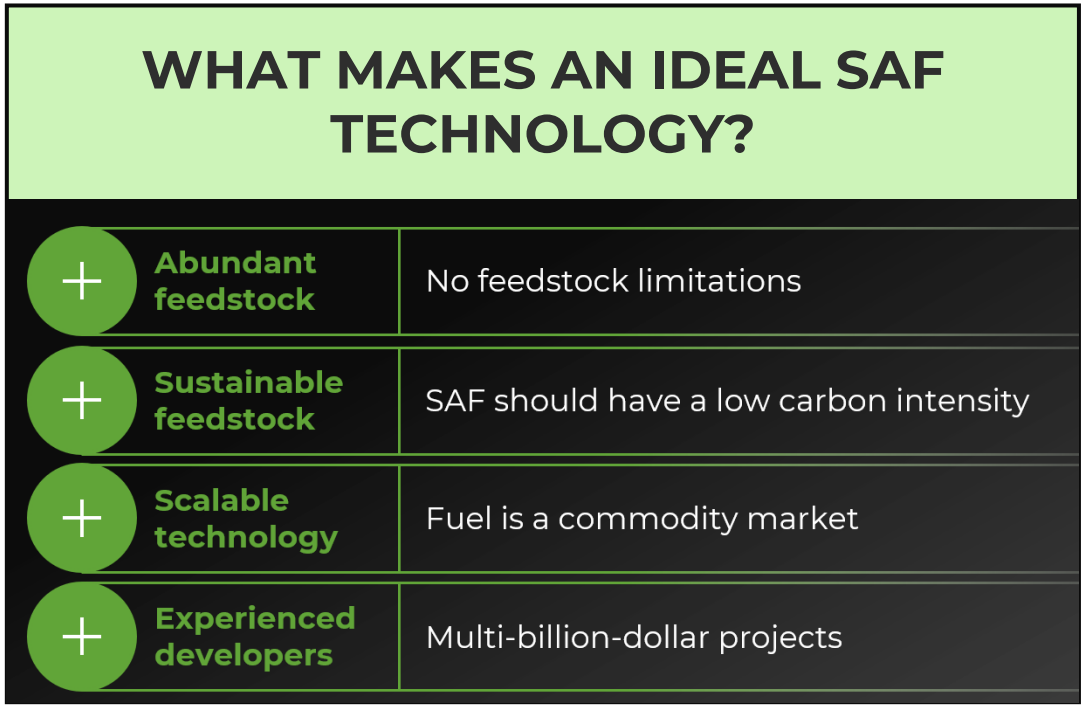
Five major pathways are competing to supply the future SAF market: bio-oil, biomass, ethanol, methanol, and CO_2 to SAF.

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.



© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

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.

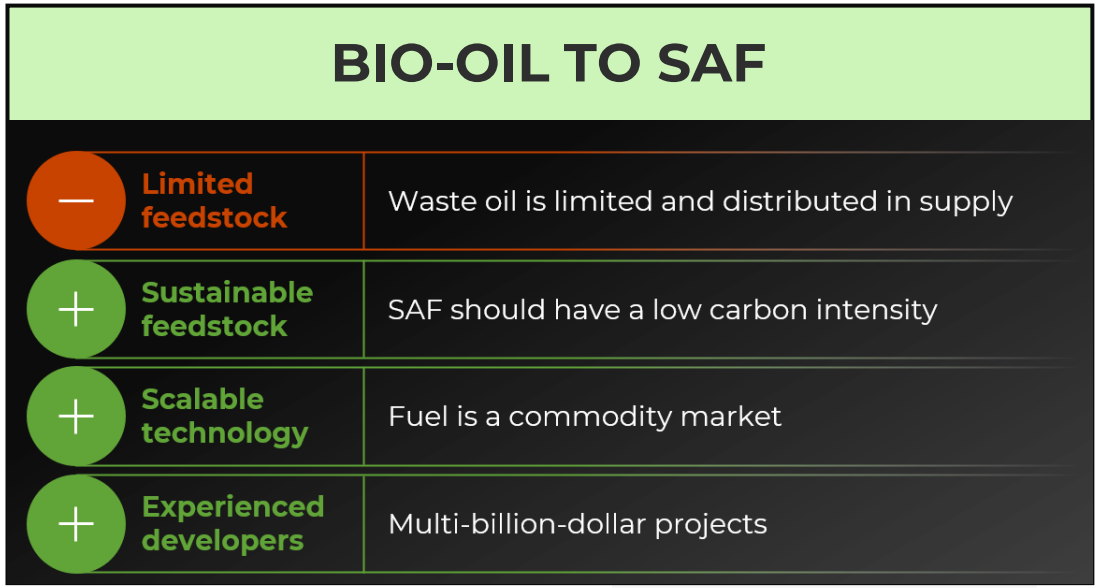
Its weakness is not technology. It is feedstock.

Waste oils like 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 like camelina
- Monitor technologies producing HEFA-compatible oils from alternative inputs

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



© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

Abundant biomass still needs a scalable conversion route

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

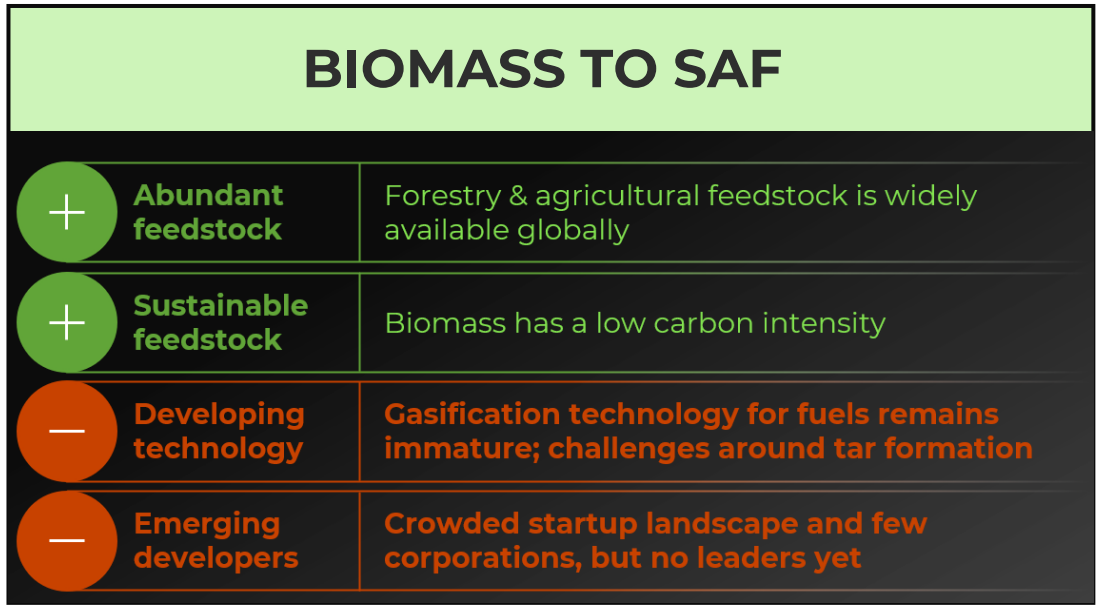
Agricultural, forestry, and other biomass residues offer something waste oils cannot: globally abundant low-carbon feedstock.

The challenge lies in converting that feedstock reliably and economically.

Gasification followed by Fischer-Tropsch (FT) 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 like Haffner Energy are working to solve these bottlenecks, but decision-makers should treat biomass to SAF as a strategic scale-up opportunity rather than a near-term replacement for HEFA.



© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

*ASTM International, American Society for Testing and Materials International

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 (ETJ) has an important advantage: Its conversion technology is backed by experienced licensors and can leverage established ethanol supply chains.

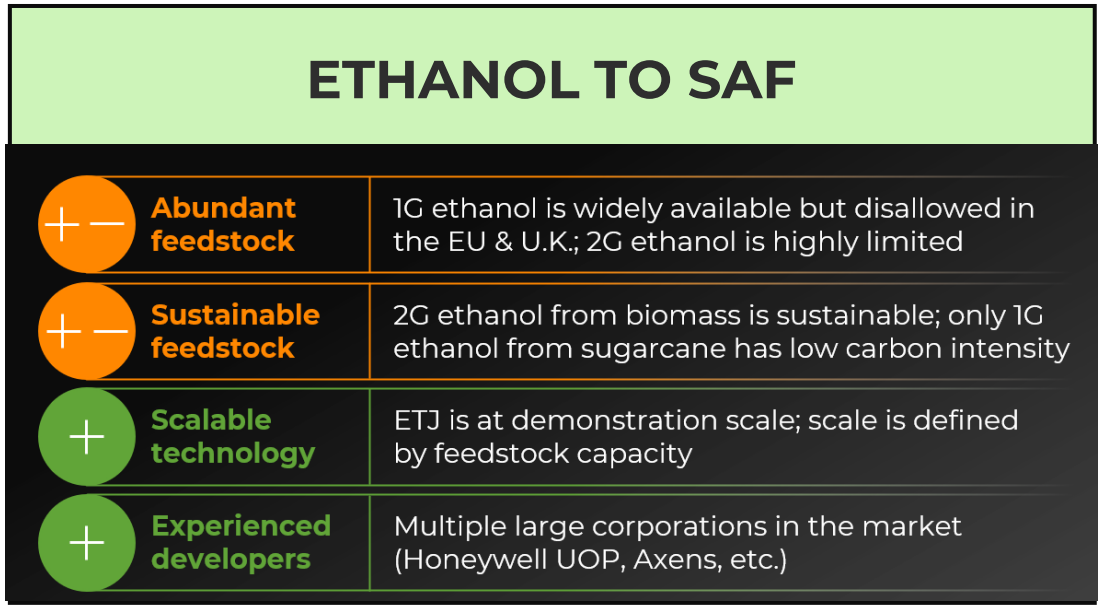
The major constraint is regulatory.

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



© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

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

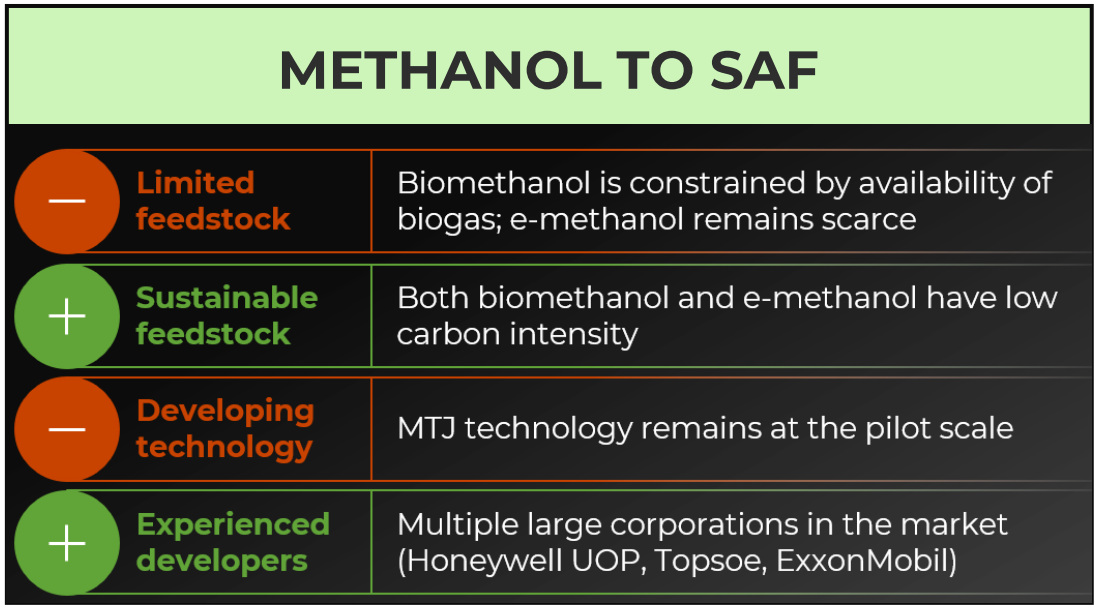
Key takeaway: *Methanol to SAF combines mature technology developers with lower projected costs than CO_2 to SAF, but feedstock availability remains constrained.*

Methanol to SAF converts low-carbon methanol into jet fuel (MTJ) 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 hurdles, Lux's analysis indicates methanol to SAF offers a lower-cost e-SAF route than CO_2 to SAF.

Companies required to meet e-SAF mandates should prioritize methanol to SAF. The strongest opportunities may come from sourcing low-carbon methanol from regions with cheaper renewable electricity and importing it into demand centers.



© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

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

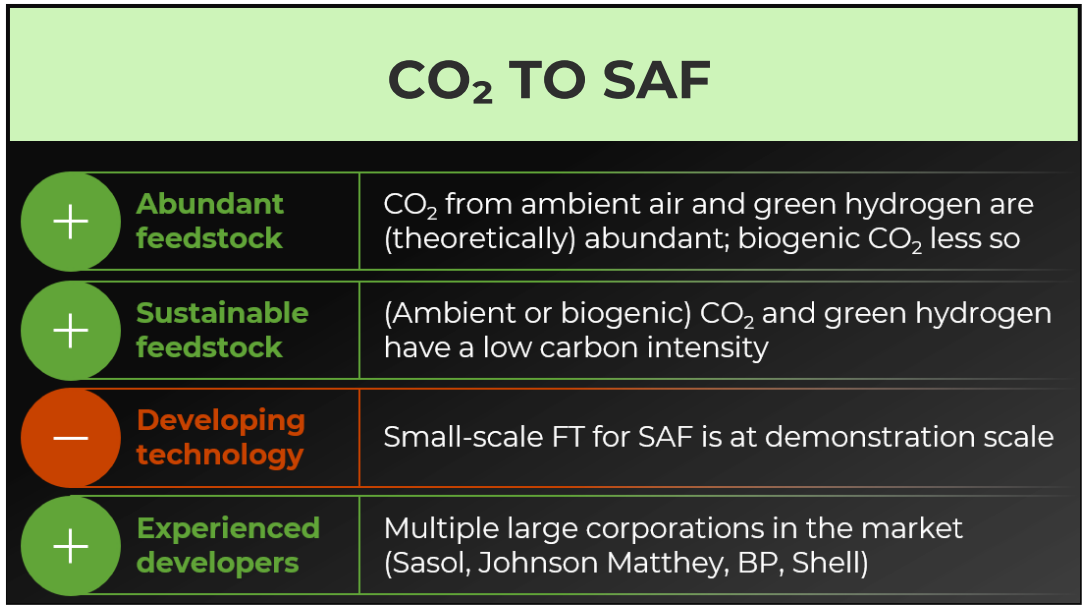
Key takeaway: *CO_2 to SAF could unlock abundant low-carbon feedstocks, but technology scale-up and green hydrogen costs limit near-term deployment.*

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

Key challenges include:

- Small-scale FT 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 like OXCCU and Twelve are working to simplify the process and lower capital requirements. But both remain at demo scale. CO_2 to SAF should be treated as a longer-term strategic option, especially where e-SAF mandates justify higher costs.



© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

Cost will determine which pathways actually scale

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

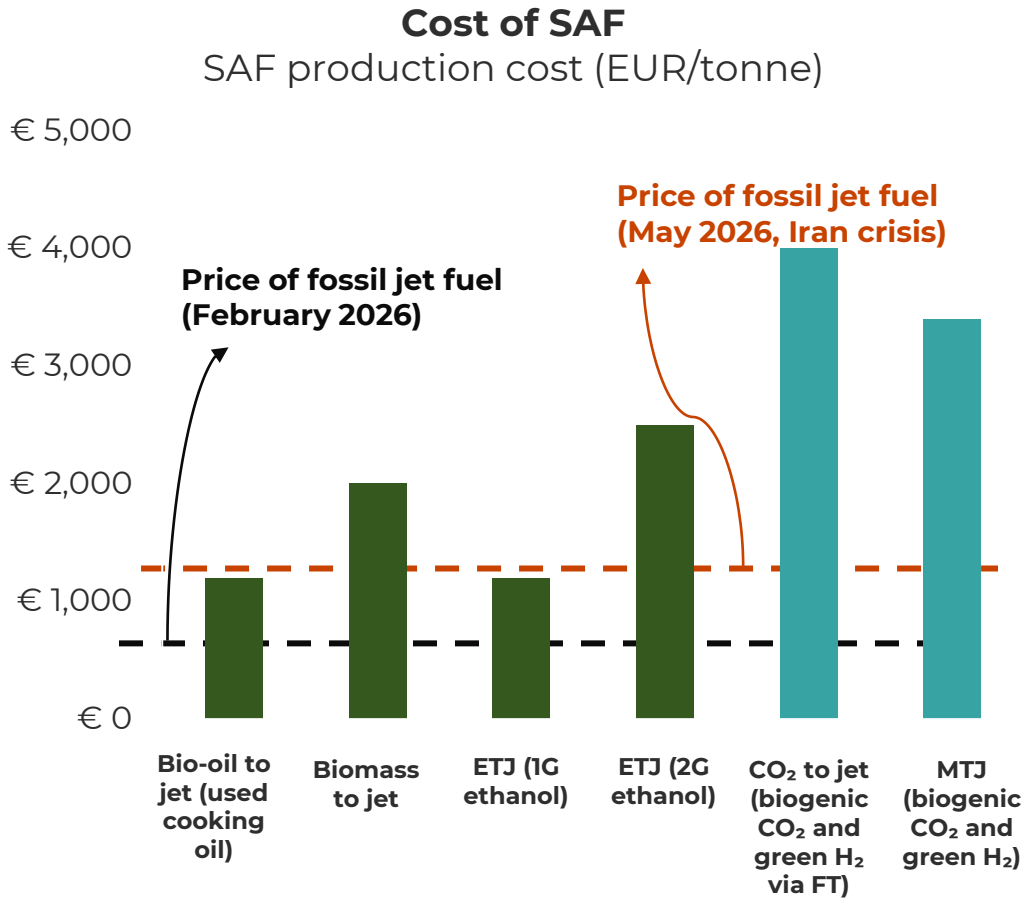
Lux's analysis assumes mature, optimized production at approximately 1 million tonne per year. Even under those conditions, significant premiums remain.

Approximate production costs include:

- Bio-oil to jet: EUR 1,200/tonne
- Biomass to jet: EUR 2,000/tonne
- 1G ethanol to jet: EUR 1,200/tonne
- 2G ETJ: EUR 2,500/tonne
- CO_2 to jet: EUR 4,000/tonne
- MTJ: EUR 3,400/tonne

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

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



© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

WHERE TO PRIORITIZE

Build the SAF portfolio in 3 steps

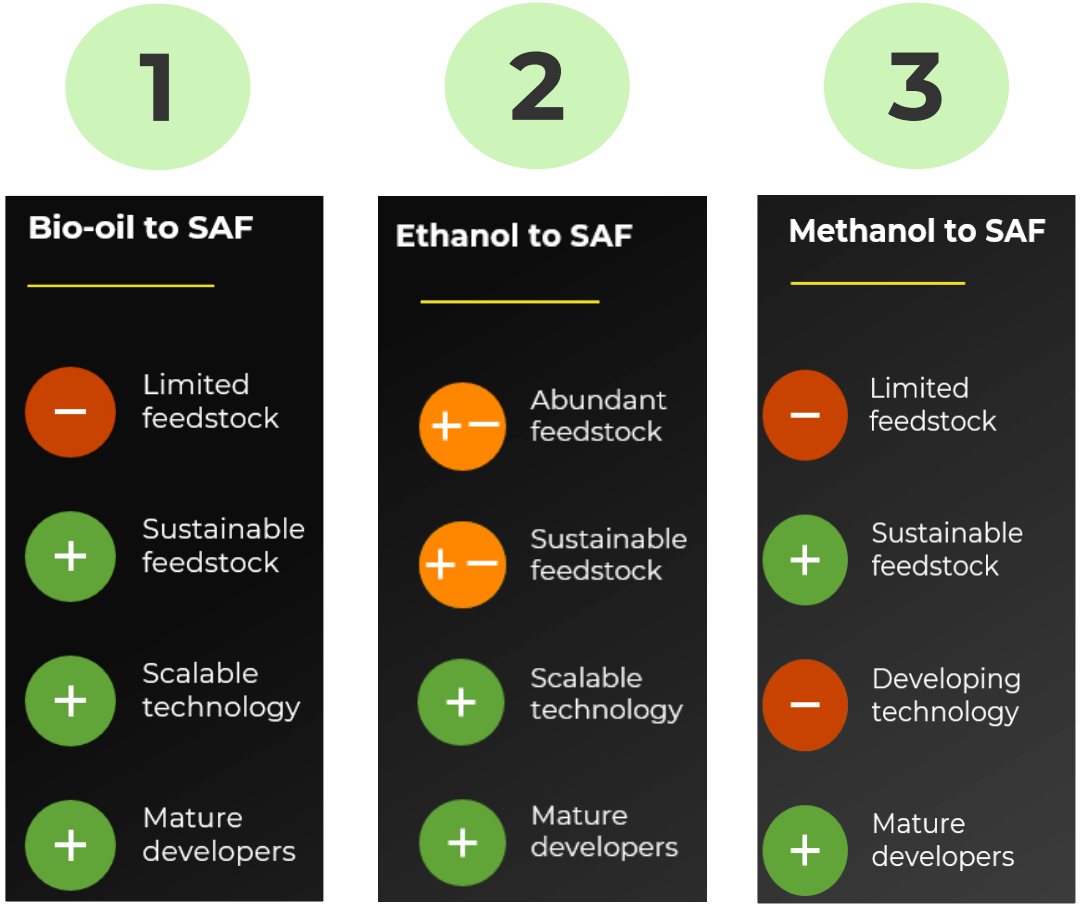
Key takeaway: *Prioritize commercial readiness first, scalable feedstocks second, and e-SAF only where policy requires it.*

Decision-makers 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 ETJ.** Where regulation allows, use established ethanol infrastructure to create the next major source of SAF capacity.
3. **Choose MTJ 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.



© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

Make More Confident Innovation Decisions with Lux Research

Strategic Foresight & Market Opportunities

Where should we focus innovation efforts?

Technology Scouting & Assessments

Which technologies deserve investment?

Startup Discovery & Validation

Which partners can accelerate innovation?

© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential

About Lux

Lux Research fuels innovators to not only imagine what's possible in the future but also operationalize innovation success in the near term. We deliver research and advisory services to inspire, illuminate, and ignite innovative thinking that reshapes and grows businesses. Using quality data derived from primary research, fact-based analysis, and opinions that challenge traditional thinking, our experts focus on finding truly disruptive innovations that are also realistic and make good business sense.

The "Lux Take" is trusted by innovation leaders around the world, many of whom seek our advice directly before placing a bet on a startup or partner — our clients rely on Lux insights to make decisions that generate fantastic business outcomes. We pride ourselves on taking a rigorous, scientific approach to avoid the hype and generate unique perspectives and insights that innovation leaders can't live without.

READ

http://www.luxresearchinc.com/blog/

VISIT

www.luxresearchinc.com

EMAIL

questions@luxresearchinc.com

CONNECT

LuxResearch

© LUX RESEARCH, INC. | All rights reserved. | Lux Proprietary and Confidential