Affordable, Sustainable Aviation Energy

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Our view on sustainable aviation





Fleet renewal

Advanced technology

Operational efficiency

Renewable energy

Offsets & removals

Non CO_2 emissions and effects

Design, produce, and operate energy efficient aircraft

Pathway to sustainable aviation

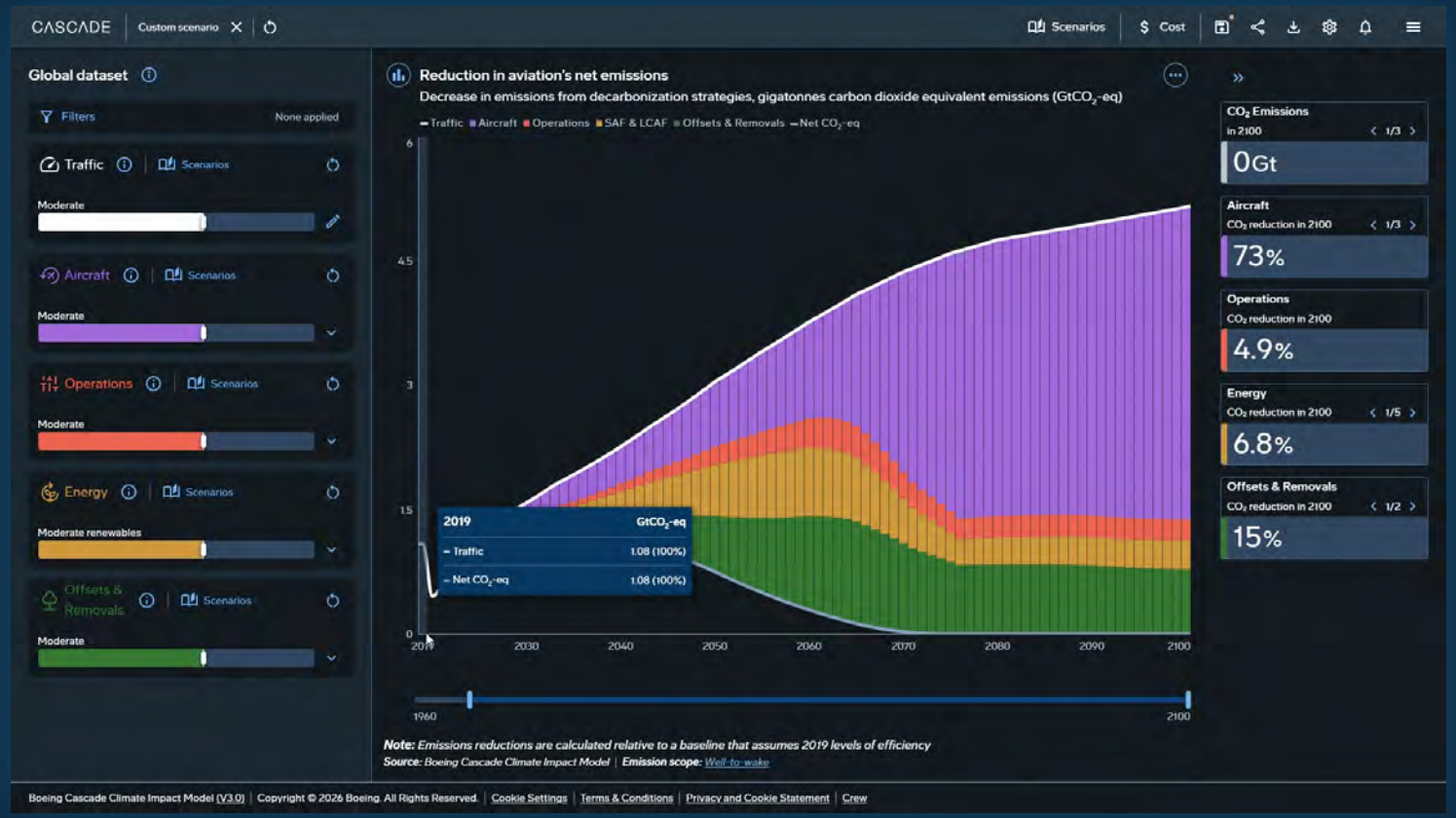
Enable airlines to fill their tanks with renewable content at minimum cost as soon as possible

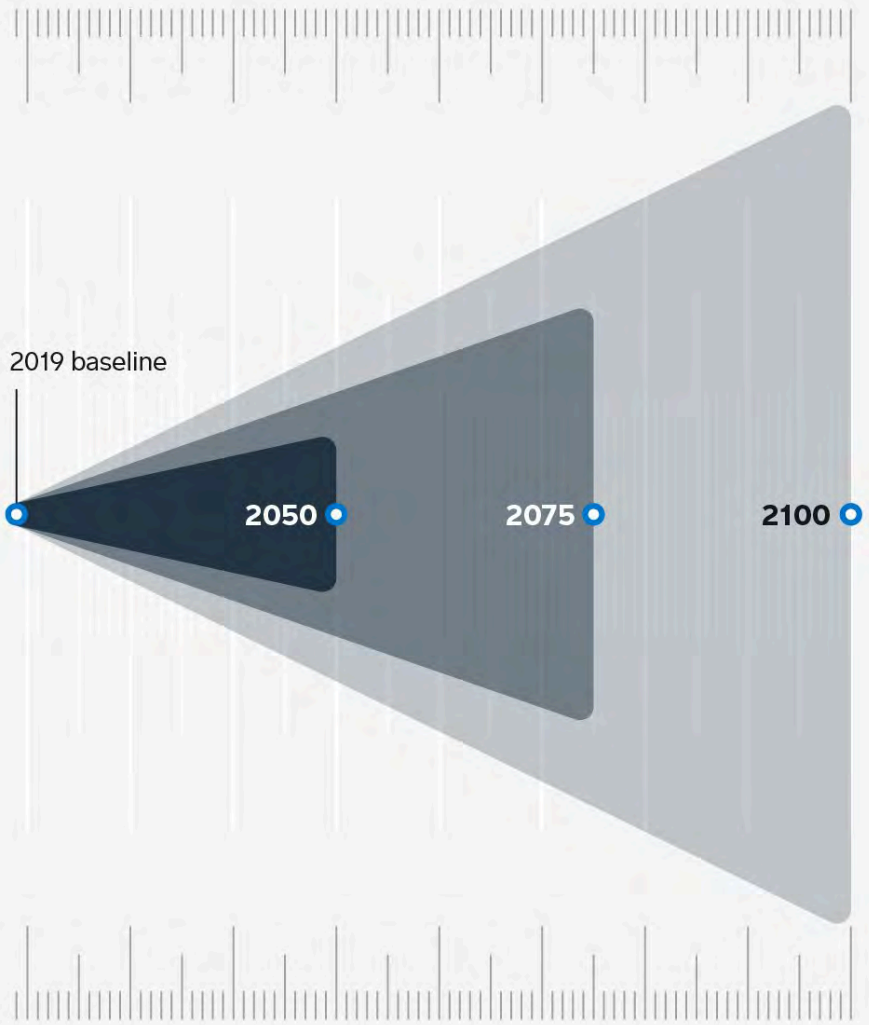
Powered by the Boeing Cascade Climate Impact Model

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Using Cascade to look across different time scales

What's the timeline of your scenario?
Select an end year or set your own.





What will power aviation’s future?



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Key takeaways: addressing climate change, at lower cost

Co-processing SAF

Adapt petroleum refineries to produce SAF, lowering production costs while increasing supply

Near-to long-term

Addressing non -CO_2



Reroute small proportion of flights to reduce the impact of persistent contrails

Near-to long-term

The opportunity

Near-to long-term

Scaling carbon removals

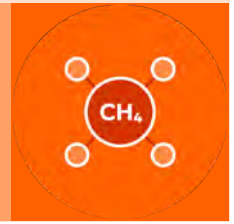
Expand the global supply of permanent carbon removals



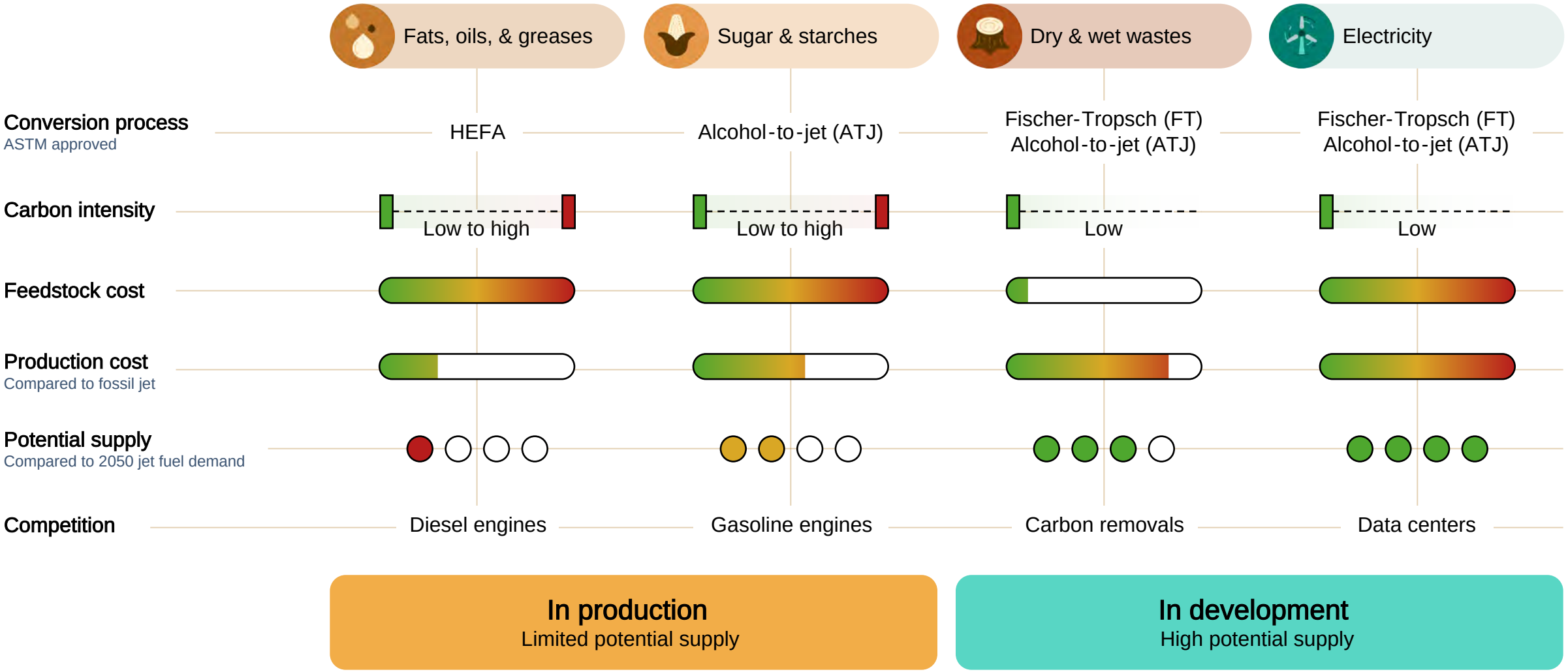
Long-term

Researching renewable methane

Evaluate methane fuel as a potential complement to jet fuel/SAF

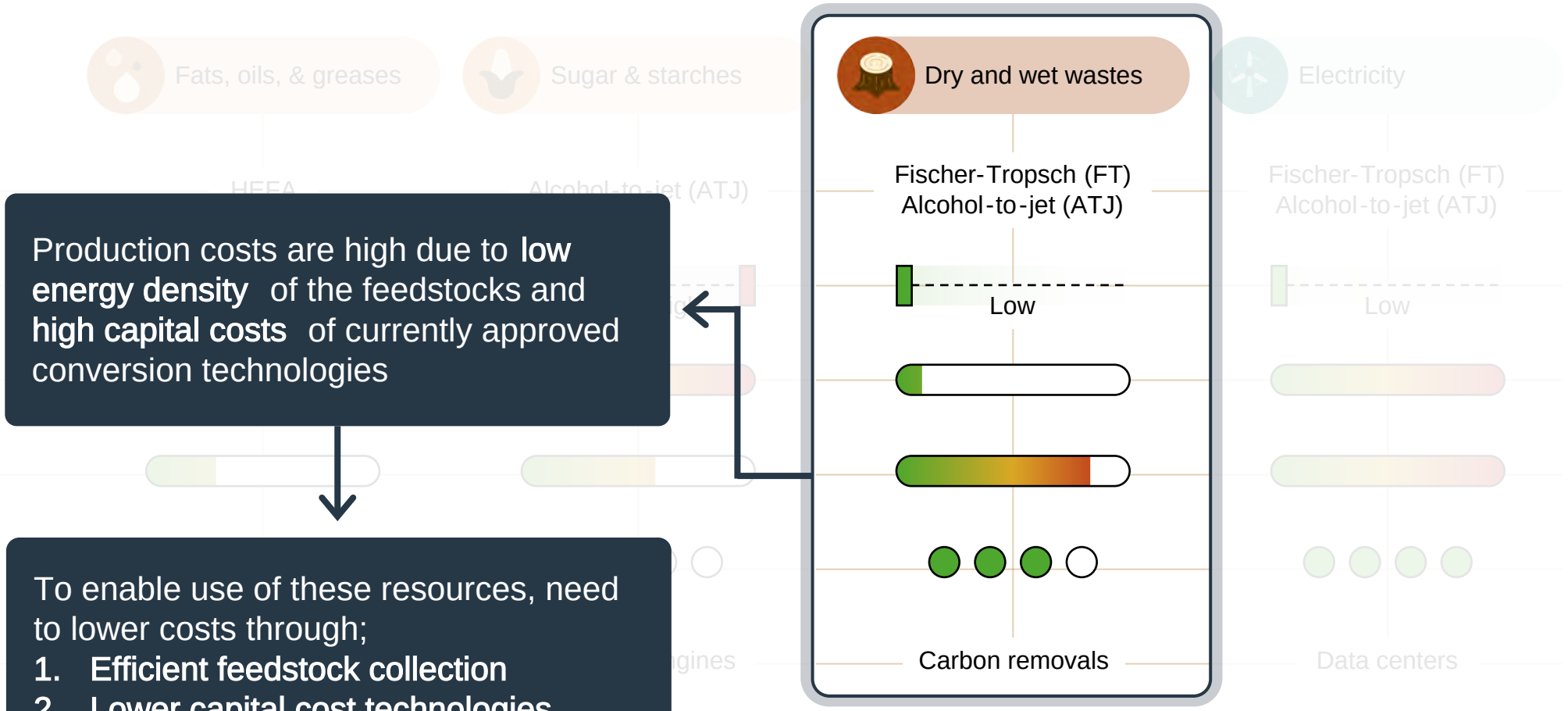


Comparing types of SAF



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Comparing types of SAF



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Working with existing refinery resources

The opportunity:

- Gasoline and diesel demand will fall as cars and trucks electrify. Jet fuel demand is expected to grow for decades to come.
- As a result, the petroleum refining industry is going to evolve.
- An opportunity exists to leverage refineries to produce SAF from FOGs, sugars and starches, and solid bioresources.

Co-processing options:



Co-processing with conventional jet fuel

Introduce SAF feedstocks into existing refinery units; currently limited to low - percentage introduction of fats, oils, and greases.



Co-location with conventional jet fuel

Locate SAF plant next to existing refinery. Access to site, shared utilities, logistics.



Conversion of existing plants

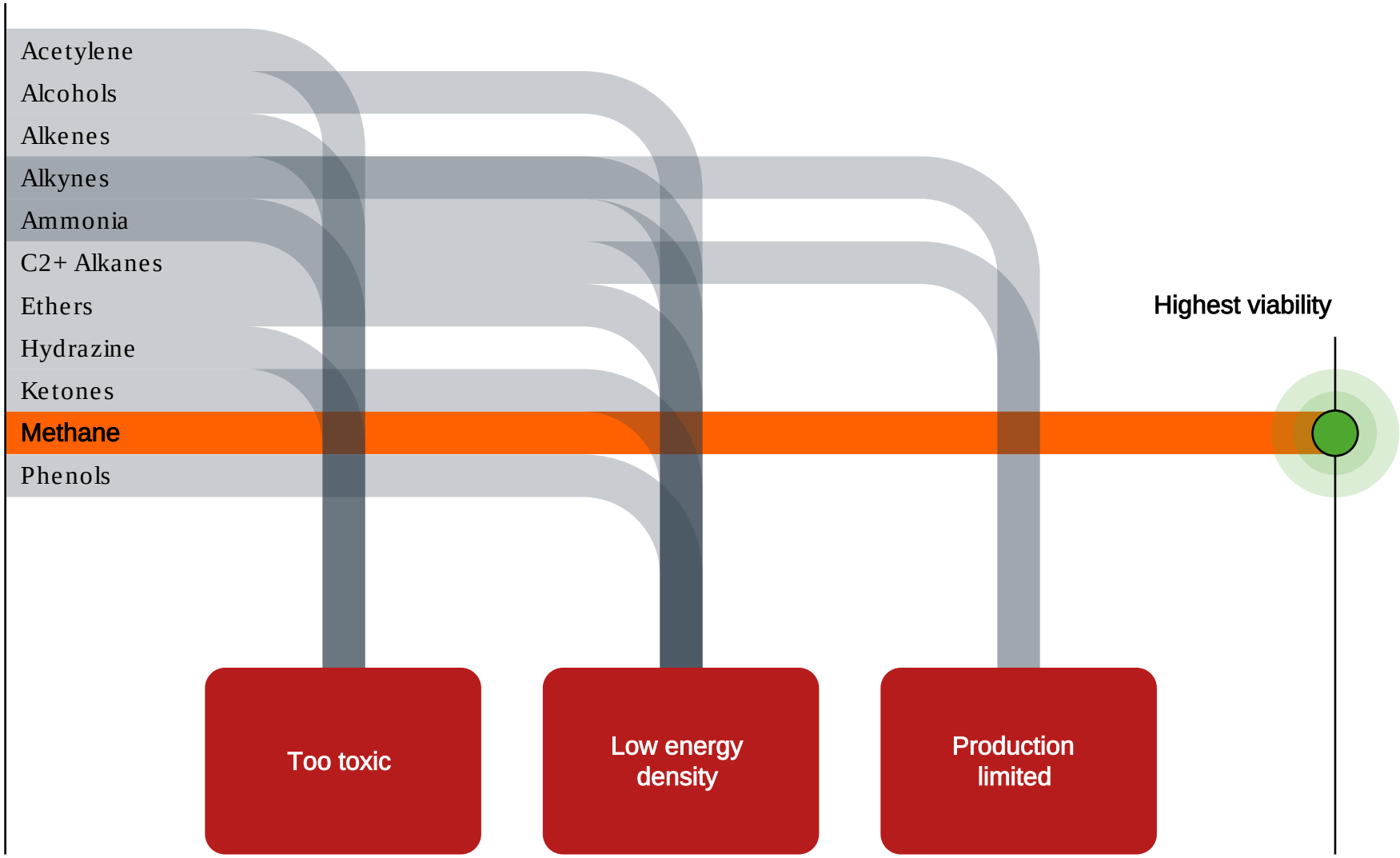
Repurpose existing refineries to convert renewable feedstocks into SAF.

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Potential energy carriers and the rationale for methane

Principle

- Comprised of C, H, O, and/or N
- Stable storage
- Health risks and safety
- Combustible and energy dense
- Readily producible



Source: Hansson, N., King, B., & Abel, J. M. 2026. *Future Energy Carriers for Aviation*. The Boeing Company.

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Diving deeper into energy carriers

Energy carrier assessment compared to conventional jet fuel

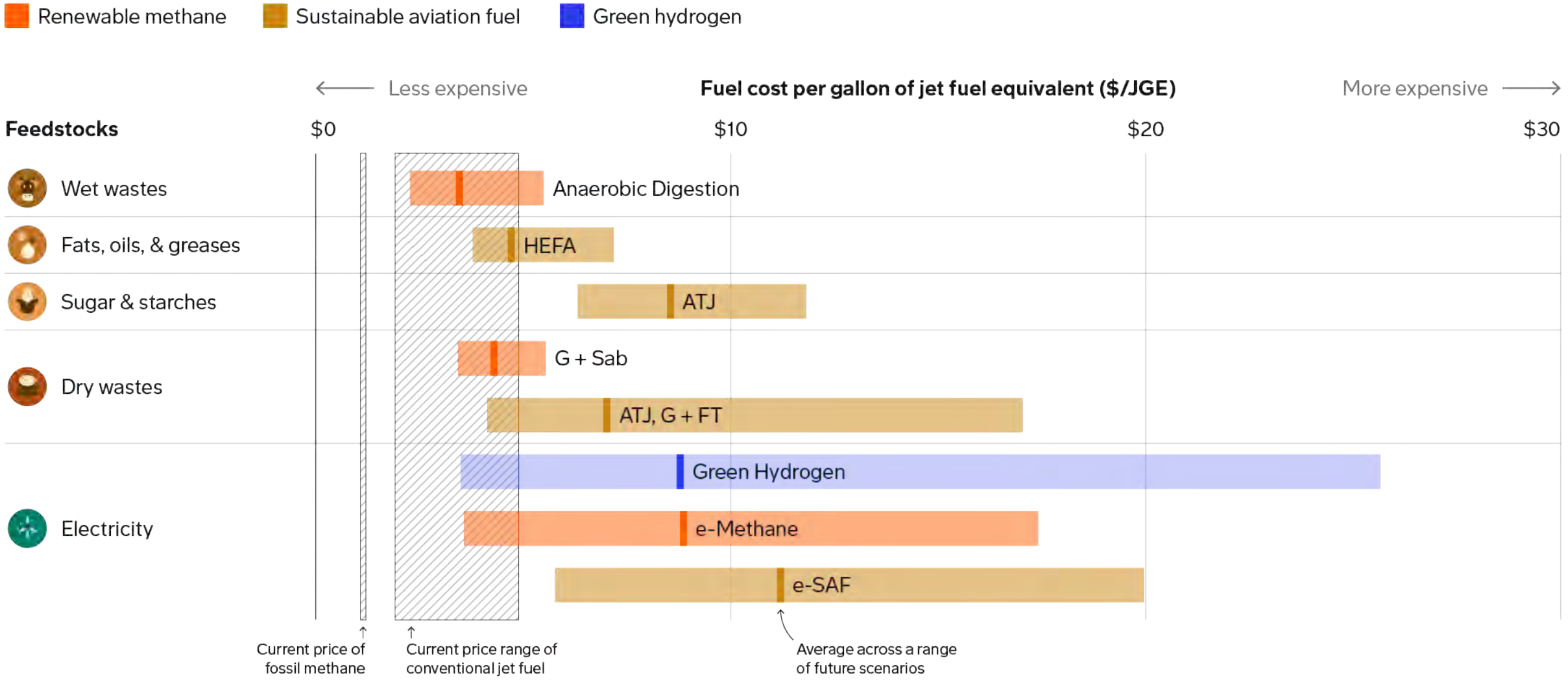
Major advantage Possible with investment Severe challenge

	Drop-in SAF	Non-drop-in SAF	Renewable methane	Batteries	Hydrogen
Energy source	Electricity and renewable feedstocks	Electricity and renewable feedstocks	Electricity and renewable feedstocks	Electricity	Electricity
Climate impact	Feedstocks and grid	Feedstocks and grid	Feedstocks and grid; fugitive emissions	Grid	Feedstocks and grid; fugitive emissions
Aircraft design	Existing	Updated designs	Updated designs or new designs	Range limited	Research advancements and new designs
Distribution infrastructure	Existing	Existing	Existing but needs connecting to airport	Existing but needs connecting to airport	None
Airport infrastructure	Existing	New fueling infrastructure	New fueling infrastructure	New charging infrastructure	New liquefaction technology and fueling infrastructure
Fuel availability and cost	Scale-up difficult and expensive	Scale-up difficult and more expensive	Widely available at relatively low costs	Energy source	Uncertain

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Renewable methane is attractive for its production costs

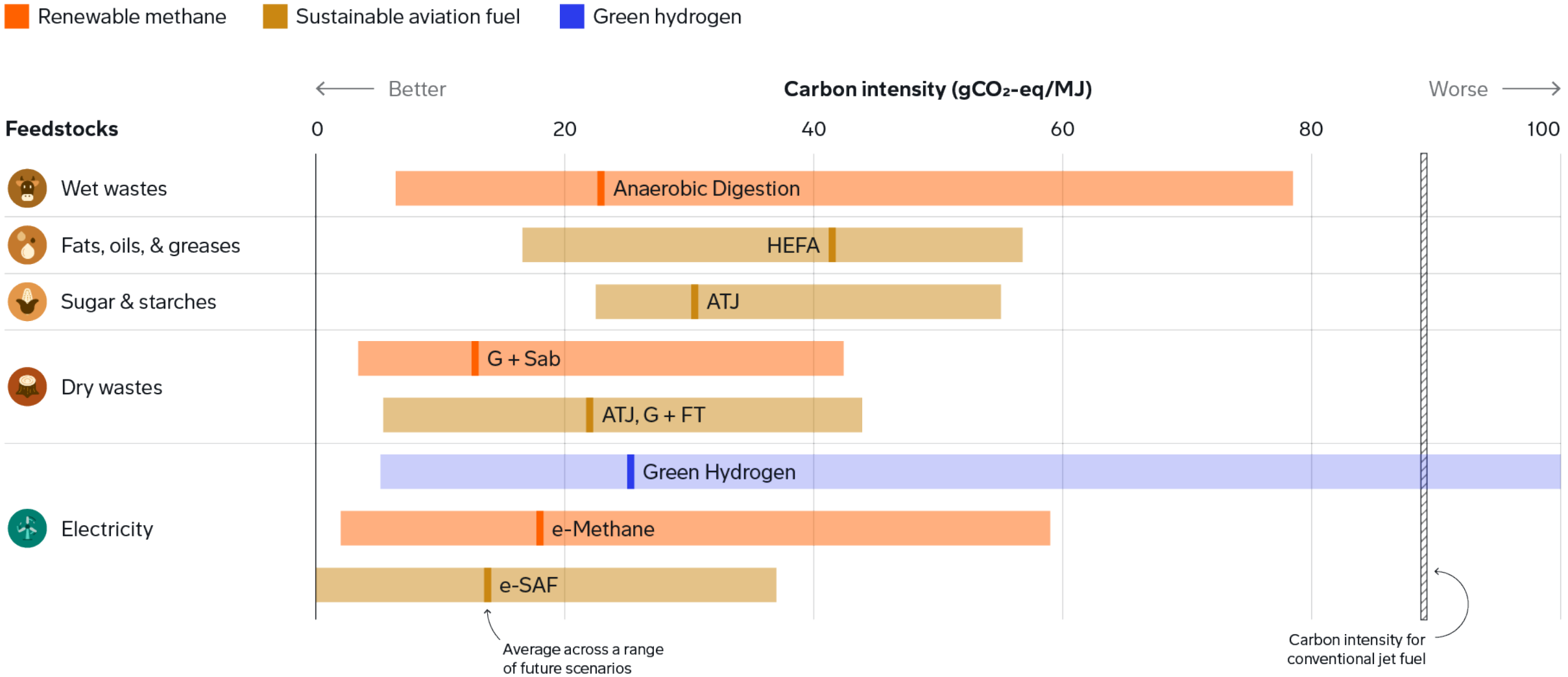
Fuel cost in 2050 in USD per gallon jet fuel equivalent



Source: NASA AACES 2026 Study, range of conventional jet fuel prices from www.airlines.org/dataset/argus -us-jet-fuel-index/

With vapor loss management, renewable methane has favorable emissions

Expected range of life cycle carbon intensities of various fuels in 2050



Source: NASA AACES 2026 Report

Tackling vapor loss

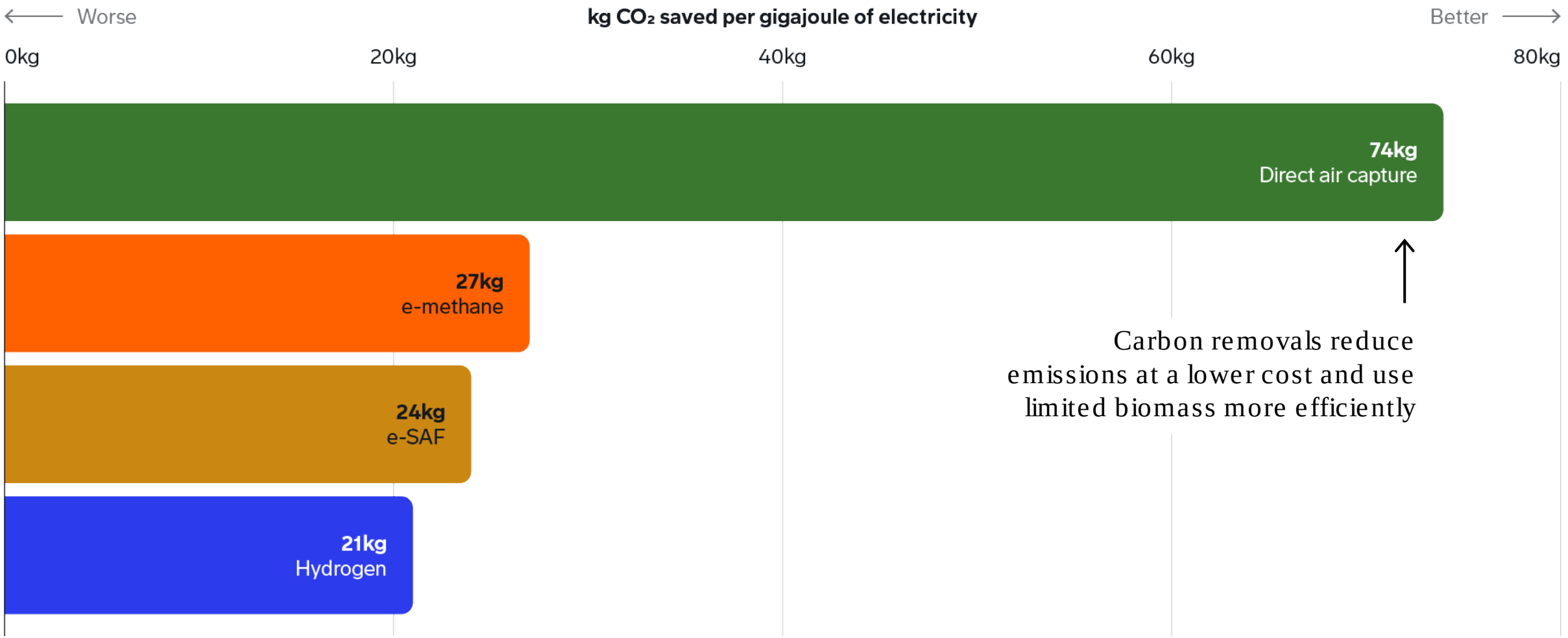
Discover how fugitive emissions can impact the feasibility of alternative aviation fuels



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Effectiveness of permanent carbon removals

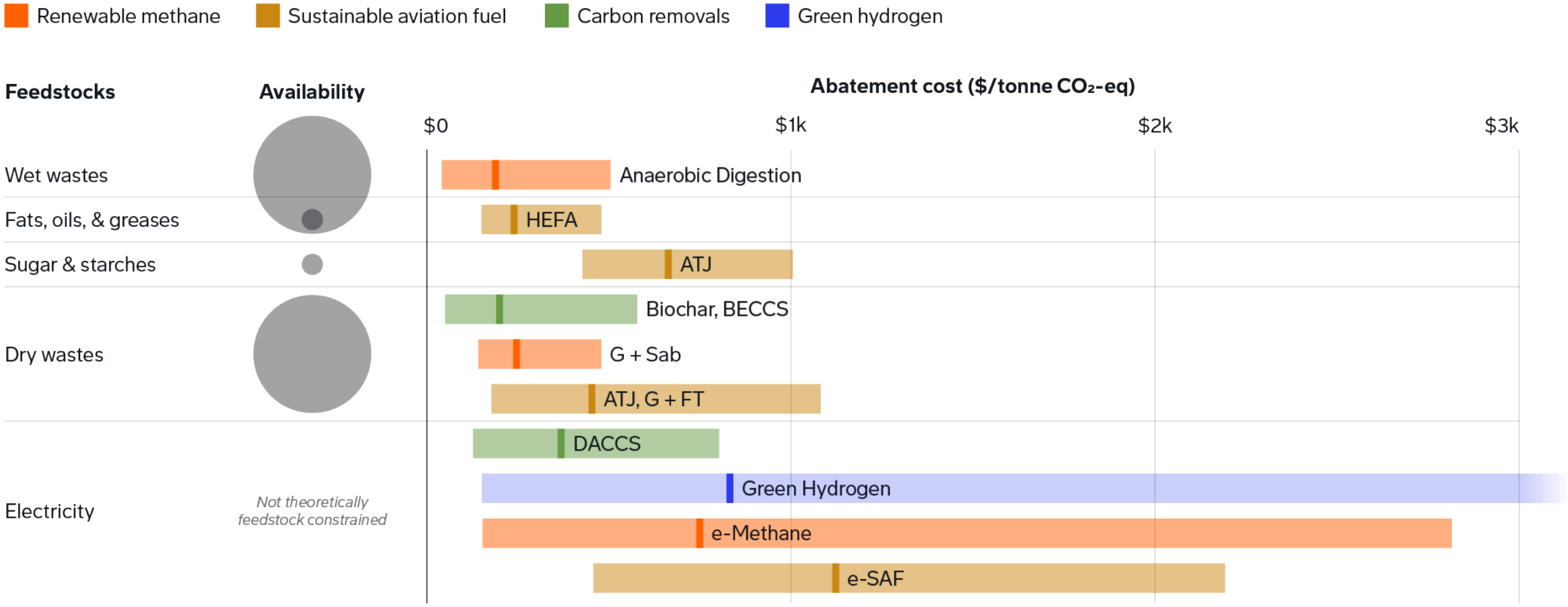
Direct air capture could be a more efficient use of electricity than e -fuels



Source: Boeing Cascade Climate Impact Model

There may not be one “best” use of feedstocks for aviation decarbonization

Estimated resource availability and 2050 cost of abatement



Source: NASA AACES 2026 Report. Feedstock availability is global estimated availability in 2050; reference jet A price of $205; all prices n-th plant

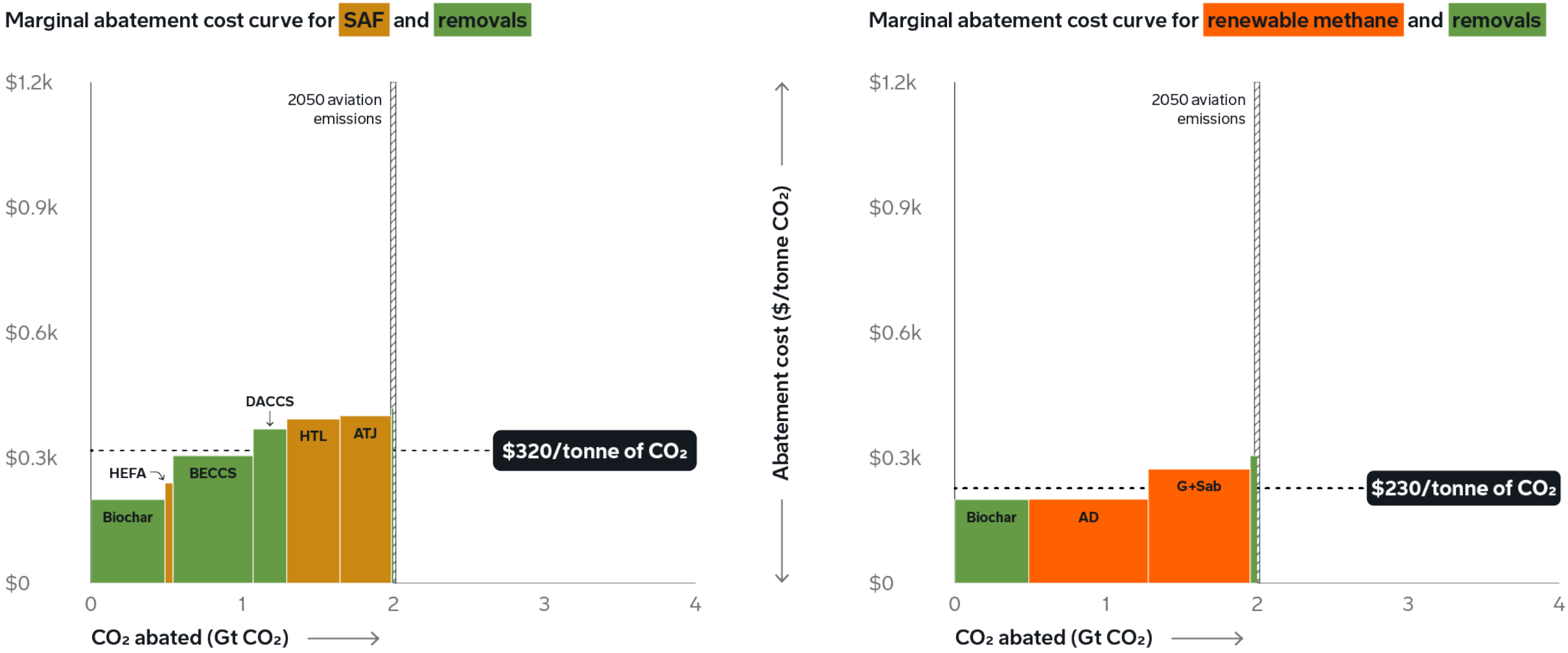
Learn more about methane beyond 2050

Visit the Cascade website to read about the possible challenges, airport infrastructure, and viability of using methane fuel for the future

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Under some scenarios methane could abate emissions more cheaply than SAF

Marginal abatement cost in USD per tonne CO2

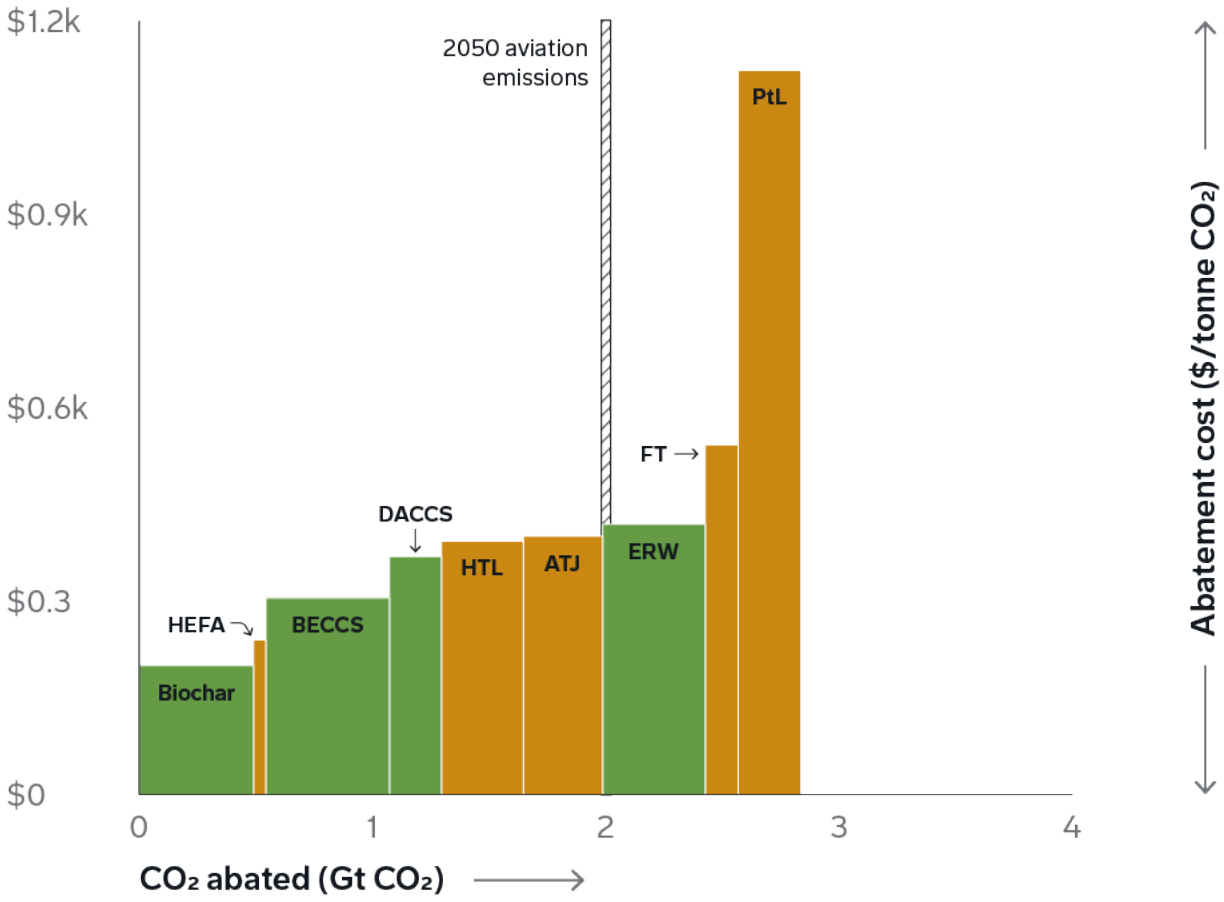


Source: Boeing Cascade Climate Impact Model. Feedstock availability is global estimated availability in 2050; reference conventional jet fuel price of $2.05; all prices n-th plant

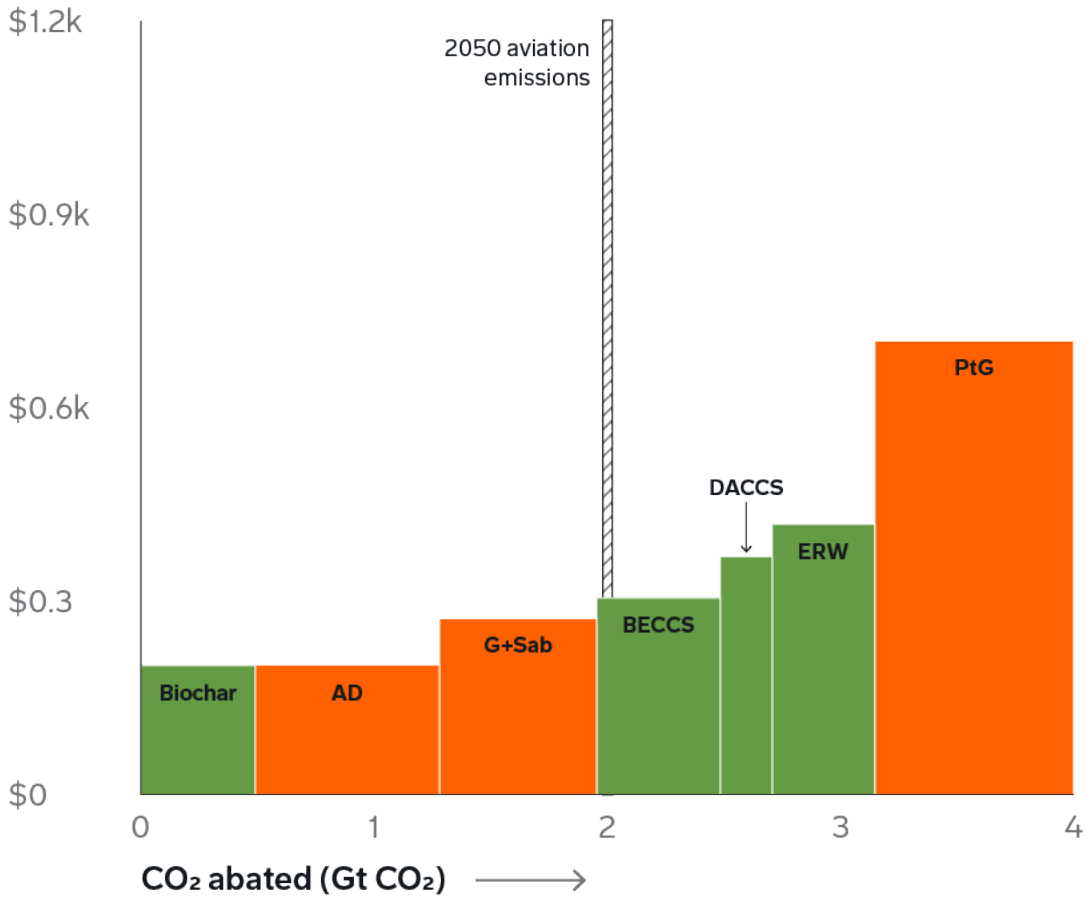
…and abate more emissions overall

Marginal abatement cost in USD per tonne CO2

Marginal abatement cost curve for SAF



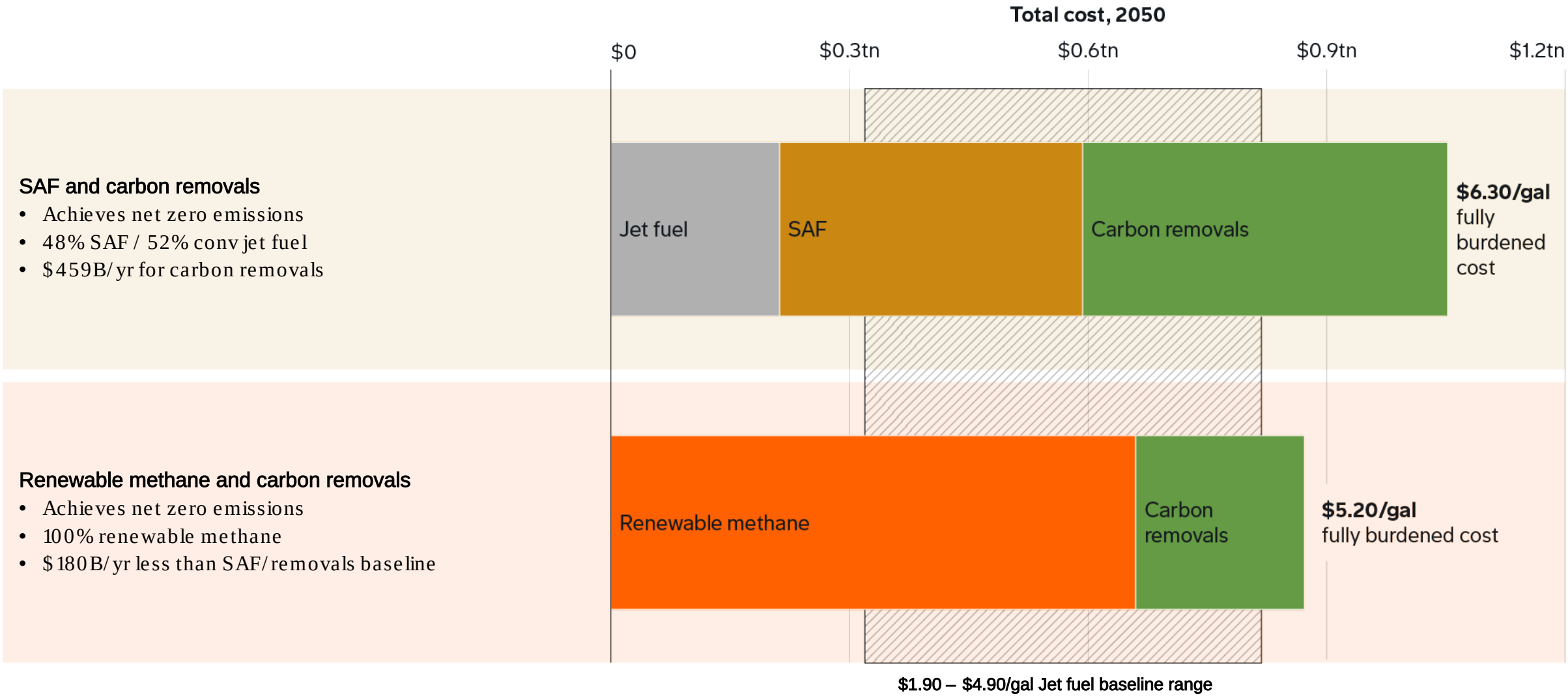
Marginal abatement cost curve for renewable methane



Source: Boeing Cascade Climate Impact Model. Feedstock availability is global estimated availability in 2050; reference conventional jet fuel price of $2.05; all prices n-th plant

Methane could be competitive today and in a zero -carbon world tomorrow

The cost of fueling aircraft USD total and USD per jet gallon equivalent



Source: Boeing Cascade Climate Impact Model, range of conventional jet fuel prices from www.airlines.org/dataset/argus-us-jet-fuel-index/

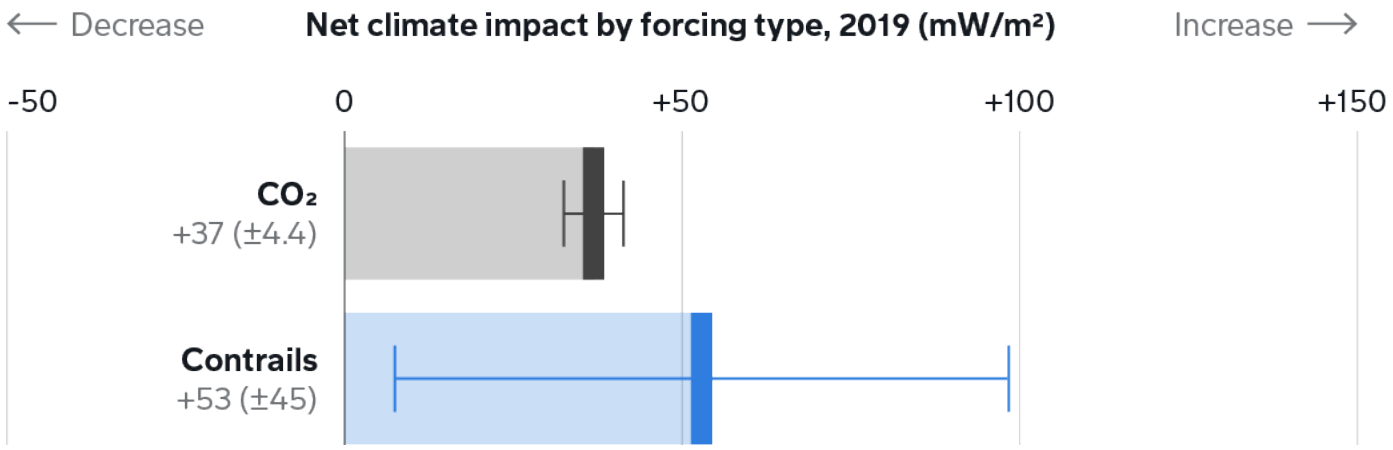
Comparing costs

Visit Cascade’s website to learn more about how the aviation industry assesses the costs and benefits of different strategies

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Persistent contrails also impact the climate

What have we learned?



Opportunities for mitigation

- Aircraft operations
- Fuel composition
- Engine and aircraft design

What research is needed?

- Actionable weather data
- Operational solutions
- Advanced climate science
- Cleaner propulsion

Source: Boeing Cascade Climate Impact Model.

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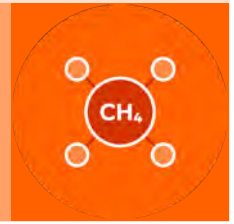
Expand the global supply of permanent carbon removals



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