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How airlines can chart a path to zero-carbon flying

The coronavirus crisis will transform aviation, giving airlines their best chance yet to address climate change. Sustainable fuels are a key part of that strategy.

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The airline industry is understandably focused on the coronavirus pandemic's impact on growth, along with the health and livelihoods of its millions of workers.

This year now represents the biggest retrenchment in the history of aviation, with airline capacity down roughly 75 percent as of early April. That means an industry with a predictably steady growth rate has suddenly shrunk to a fraction of its size. It is unclear how protracted the decline will be, though demand is likely to bottom out in 2020 before returning to pre-crisis levels several years from now. The timing will depend on many factors outside the industry's control.

In the longer term, aviation is likely to undergo structural changes with regard to demand and the degree of industry consolidation, along with unprecedented government support. That transition provides an opportunity to rebuild the industry for a low-carbon future, something that airlines have been grappling with for some time.

Even before the coronavirus pandemic began, the industry was facing the challenge of reducing its carbon emissions in line with international goals to reach net-zero emissions by 2050. Forces that have buoyed the case for sustainability—including customers and regulators worried about emissions and unpredictable future carbon policies—have shifted with the pandemic, as airlines' survival seems to be at stake.

The industry has a solid record on fuel efficiency: fuel burn per passenger-kilometer has dropped by half since 1990, according to the International Air Transport Association. The current crisis could provide forward-thinking airlines with a chance to emphasize their fuel-efficiency programs and justify the retirement of older, less-fuel-efficient aircraft (see sidebar, "Ten questions airline executives should be asking"). Modernizing fleets and improving operational efficiency are important; however, in the best case, annual industry growth counters the emissions that they save. Carbon offsetting holds more promise, and it can help serve as a bridge while the industry takes action needed to reduce its own emissions over time.

The option that could be transformative, aligning the industry's growth ambitions with Paris Agreement targets, is sustainable aviation fuel (SAF). Compared with fossil kerosene, SAF could mean a reduction in carbon emissions of 70 percent to almost 100 percent. While SAF has drawbacks, including high prices and supply concerns, airline CEOs should view it as a promising tool in their decarbonization toolkits. To help push options forward, airlines can make targeted investments and purchase commitments that would increase SAF use (currently at less than 1 percent of total consumed jet fuel) while reducing costs.

Because of the scale of the challenge, any solution will require a multistakeholder approach that also includes governments, tech players, and suppliers. The trick is to create a suitable regulatory framework and supporting incentives so that no single player is penalized for going it alone.

The case for action

The aviation industry has taken steps to address rising emissions. In 2009, it set ambitious targets that include carbon-neutral growth from 2020 onward and halving its net emissions from 2005 levels by 2050.

We don't know what the pandemic will mean for emissions growth over time. But the target for all industries, companies, and countries is to reach net-zero carbon emissions by 2050, as laid out in the Intergovernmental Panel on Climate Change goals of limiting global warming to no more than 1.5°C above preindustrial levels. As the energy and transportation industries create a path to decarbonize, sectors in which climate effects are hard to abate are coming under more pressure, and aviation is no exception. McKinsey recently developed a set of

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1.5°C scenarios that would see reductions in aviation emissions of 18 to 35 percent compared with a business-as-usual pathway by 2030.[1]

Nations excluded aviation and international shipping when setting carbon targets because emissions are difficult to allocate to a particular country. But airlines shouldn't risk the perception that they aren't doing enough about CO_2, especially amid mounting scrutiny from the flying public, the media, investors, and regulators. With half of industry growth coming from Asia, including China, India, and Southeast Asia, decarbonization can work only if airlines from those nations are on board.

Despite the convenience of flying, consumers have said they are increasingly worried about the impact it has on climate change. Public movements, such as #flygskam ("flight shaming") and Fridays for Future, reflect this sentiment, particularly among millennials.

Investors, for their part, are concerned about the effects of climate risk on airline valuations, with climate-related financial disclosures becoming more common. The frequency of climate-related discussions in European earnings calls with investors increased nearly sevenfold since 2017, according to HSBC data. At the same time, corporate customers turn to airlines for ways to reduce scope-3 emissions[2] incurred from their employees' business travel.

Institutions and governments are announcing policies on CO_2 or SAF. Norway has mandated that 0.5 percent of aviation fuel in the country must be sustainable this year, growing to 30 percent by 2030. It wants all short-haul flights to be 100 percent electric by 2040. And Canada implemented a carbon tax of 30 Canadian dollars (around $21) per metric ton of CO_2 in most of its regions, based on the amount of loaded fuel for domestic travel.

Much of the pressure is rooted in consumer unease. Last summer, McKinsey conducted a survey of roughly 5,300 fliers in 13 aviation markets to get their views on flying and climate change. Although the survey took place well before the coronavirus essentially shut down air travel, more than 50 percent of respondents said they were "really worried" about climate change. Those feelings were higher among women than men and most pronounced among people aged 34 and younger, suggesting that these perceptions aren't going away (Exhibit 1).

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[1] The scenarios include assumptions about improvements in energy efficiency (driven by operational improvements and fleet modifications), the share of zero-emission sustainable aviation fuel in the fuel mix, and reduced travel demand and modal shifts. 2016 was the baseline used for all scenarios, and the business-as-usual outlook is based on McKinsey's 2019 Global Energy Perspective.

[2] Scope-3 emissions are all indirect emissions that occur in the value chain of a reporting company. For an airline, they would include the emissions involved in manufacturing the plane and in preparing the food that people eat in flight, for example.

Exhibit 1

Younger airline customers are more concerned about climate change, our survey showed.

Attitudes toward carbon-neutral flying, by age group, % of respondents

	Really worried about climate change	Aviation plays a major role in carbon footprint	Have a bad conscience when flying	Aviation should definitely become carbon neutral	Plan to reduce own air travel	Willing to pay ≥$20 for carbon-neutral flight[1]
18–24 years	52	41	34	59	40	55
25–34 years	62	46	40	62	38	56
35–44 years	56	42	34	56	34	47
45–54 years	49	34	21	44	24	37
55–64 years	46	33	14	39	20	35
≥65 years	44	30	13	42	18	34
Total	54	40	30	53	31	46

[1] For a $1,000 flight.

Source: McKinsey CleanSky Survey, July 2019

Roughly a third of respondents said they were planning to reduce their air travel because of climate concerns (Exhibit 2), and most respondents said they were willing to pay somewhat more for carbon-neutral tickets, with fliers aged 18 to 34 willing to pay the most. At the same time, respondents felt that airlines and government subsidies should cover the costs before corporate customers or fliers themselves did. When asked about feasible ways to decarbonize aviation, they ranked carbon offsetting as the least appropriate option.

In the short term, the coronavirus pandemic and the resulting demand shock have reduced carbon emissions. We don't know what the aviation industry will look like after the coronavirus pandemic, but we believe that customer preferences for environmental flying will continue.

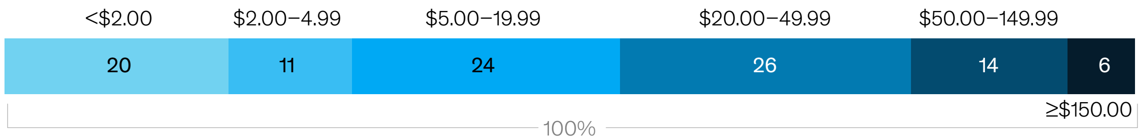
Tech and efficiency gains

Airlines are already working to align emissions cuts with their bottom-line interests. They have encouraged operational efficiency and optimal air-traffic management (ATM) and invested billions of dollars to modernize aircraft with more efficient aerodynamics and engines using lighter-weight materials. However, these actions get the industry only so far, cutting emissions by no more than 20 to 30 percent compared with the do-nothing alternative.

Exhibit 2

Many respondents say they are planning to fly less and are willing to pay more for carbon-neutral tickets.

Willingness to pay for carbon-neutral flight, by added cost,[1] % of respondents



33%
of respondents believe (other) people should fly less because of climate change

31%
of respondents are at least "likely" planning to fly less because of climate change

8%
of respondents are "definitely" planning to fly less because of climate change

Note: Figures may not sum to 100%, because of rounding
[1] Based on a $1,000 flight.
Source: McKinsey CleanSky Survey, July 2019

Operational efficiency
Fuel typically accounts for 20 to 30 percent of operational costs—one of the largest single cost items. Every kilogram of kerosene produces 3.15 kilograms of CO_2.[3] Airlines therefore have an intrinsic motivation for adopting more fuel-efficient flying, taxiing, and airport operations. They are also eking out fuel-efficiency gains by decreasing the extra fuel loaded onto aircraft and introducing lighter materials to reduce aircraft weight.

In a recent survey of airlines, we learned that, despite these efficiency gains, carriers capture only around 50 percent of their full potential. Only a few airlines address their employees' behaviors and mindsets related to fuel. This is a crucial area, since pilots, dispatchers, and other airline employees have considerable discretion in preparing and conducting safe flights, with direct implications for fuel consumption.

To increase fuel efficiency, airlines should identify the areas needing improvement with the help of analytics and systematically drive behavioral change with their frontline employees. For example, in a behavioral-science project, Virgin Atlantic Airways successfully demonstrated how nudging, or using subtle interventions to change behavior, can make pilots use less fuel.

The airline randomly placed all 335 of its pilots into four groups. It informed the members of one group (the control group) that they were part of a fuel-use study, with no further information. It provided the experimental groups with feedback on their fuel use, including monthly assessments on fuel loading, optimized flying, and efficient taxiing. According to the researchers, all three experimental groups saved more fuel than the control group did, and pilots in the "prosocial" group—those told that the company would make a charitable donation if they reached their targets—reported the highest level of job satisfaction.

[3] "Aviation Carbon Offset Programme: Frequently asked questions," International Air Transport Association, April 30, 2020, iata.org.

Airlines also consume additional fuel from zigzagging through nations' ATM sectors that require predefined handovers. Other inefficiencies include limits on air-traffic-control capacity and a lack of automation in air-navigation services. Eliminating those inefficiencies requires a joint effort from a large group of stakeholders, including governments, regulators, and militaries, which makes the process painfully slow.

New aircraft technology

Airlines invested almost $120 billion in new aircraft in 2018 alone, according to Teal data. New models have highly efficient engines, and modern long-haul twin-engine aircraft are replacing four-engine aircraft, which enables up to 20 percent fuel-efficiency improvement per passenger.

Regarding commercial-fleet strategy, executives should consider not just fuel-price predictions but also the future cost of carbon. Applying carbon emissions as a fuel-cost premium could lead to an accelerated fleet rollover and faster adaption of future aircraft technology, including some electrification.

Alternative propulsion (such as via electricity and hydrogen) could one day replace conventional turbine-powered planes, especially smaller aircraft on shorter flights. However, the use of fully electric aircraft carrying more than 100 passengers appears unlikely within the next 30 years or longer. Given the lower energy density of batteries compared to fuels, aircraft would need to carry more than 50 kilograms of battery weight (with today's technology) to replace one kilogram of kerosene. Because battery weight wouldn't burn off the way fuel does, carrying that weight for an entire flight would require energy, creating a penalty for longer flights in particular.

Electric propulsion could start with hybrid- or turboelectric flying, enabling further improvements in fuel efficiency as jet engines become smaller and lighter, using less fuel. For example, Ampaire, a Los Angeles–based start-up, is working with Mokulele Airlines, an interisland carrier in Hawaii, on hybrid-electric flights for aircraft with around ten passengers.

Aircraft could also be powered by hydrogen, either from direct combustion (hydrogen turbine) or via a fuel cell. Hydrogen emits no CO_2 during the combustion process and allows for significant reduction of other elements that drive global warming, such as soot, nitrogen oxides, and high-altitude water vapor. (Hydrogen can also be a feedstock for SAF; more on that in a later section.)

However, liquified hydrogen would require four times the volume of kerosene, so its use would reduce space for customers or cargo. Also, airports would need new parallel refueling infrastructures, including fuel trucks able to store liquified hydrogen. Refueling time would grow for longer-range aircraft, affecting gate and aircraft utilization. Smaller aircraft powered with hydrogen could become feasible in the next decade. For aircraft with more than approximately 100 passengers, significant aircraft-technology development would be required, and infrastructure constraints would need to be overcome.

Intermodal shift

Trains and buses generate less CO_2 on a per-passenger basis than planes do (and rail freight can be a lower-emission alternative for air cargo). Airlines can work with rail and bus companies to offer a more integrated service for short connections and when alternative means of transport are available. Examples abound, often in Europe, such as the rail link between the United Kingdom and Europe that cut back the need for flying. But carbon savings here don't make a large dent in overall airline emissions,[4] nor are they a great option for airlines' bottom lines.

[4] McKinsey analysis shows that only 4 percent of worldwide emissions result from flights of fewer than 500 kilometers; 13 percent are from flights of fewer than 1,000 kilometers.

Carbon offsetting

Carbon offsetting, or CO_2 compensation, provides a large-scale and industry-agnostic means of compensating for CO_2 emissions by reducing emissions elsewhere. Airlines are on board with offsetting; indeed, the industry is expected to be a key sponsor for global reforestation. Offsetting is also the basis for such market-based measures as Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), the International Civil Aviation Organization's carbon-reduction initiative.

Offsetting allows worldwide investment in projects to compensate for emissions, independent of buyers' own efforts to reduce their footprints. Planting trees and letting them grow to capture CO_2 can cost as low as $5 to $10 per metric ton of CO_2 captured. That translates into a ticket-price increase of less than $1 per passenger on a short-haul flight. Besides nature-based solutions such as planting trees, offsetting projects can be related to resource recovery (such as methane capture from landfills), renewable energy, energy efficiency, and fuel switching, among other areas.

Yet offsetting as a longer-term solution is controversial. Some critics view it as an attempt at greenwashing. Many also worry that offsetting might relieve the pressure on buyers to reduce their emissions in other ways: they might feel better by offsetting and not consider enacting other emission-cutting measures. A credible environmental-footprint strategy includes reducing emissions through renewable fleets, fuel efficiency, and other measures as the role of SAF grows over time, in addition to offsetting emissions that remain.

Many airlines have made large offset commitments that go beyond CORSIA and offer their customers the option to pay offsetting costs themselves. Overall, however, only about 50 percent of airlines offer customers an opportunity to offset flight emissions, and the process to do so can be cumbersome, with customers redirected to a separate website to opt-in. As our survey showed, very few fliers—less than one percent—make use of voluntary carbon offsetting.

Sustainable aviation fuel

SAF is a solution that can achieve full decarbonization, but it comes with challenges on both the supply and demand fronts. When burned, SAF creates the same amount of CO_2 emissions as conventional jet fuel. The improvement results from the fact that its production process absorbs CO_2, leading to a reduction in CO_2 emissions of 70 to 100 percent on a life-cycle basis.

In a 1.5°C pathway, our analysis found that SAF would have to account for 20 percent of jet fuel by 2030, or, at a minimum, 10 percent in a scenario in which transportation lags in decarbonization compared with other sectors.

Use of advanced biofuels is a likely near-term solution. The technical feasibility of fuel made from vegetable or waste oils is proven, the product is certified, and some airlines use the fuel in daily operations. But getting the appropriate feedstock and supply chain in place is difficult; building production facilities and refineries is costly. Used cooking oil, a popular ingredient for biofuel, has fragmented availability and is expensive to collect. Other vegetable oils have high costs of production, collection, transportation, and conversion to fuel.

Feedstock resources also involve other environmental risks, such as deforestation and the creation of monocultures. Feedstock sources for biofuels must be selected thoughtfully to limit "food versus fuel" challenges.

Some airlines, including Cathay Pacific Airways and United Airlines, have invested in facilities to demonstrate how municipal household waste could be gasified and subsequently turned into jet fuel. In some regions, the fermentation of wood residues into sustainable kerosene has shown potential as a viable path.

Alternatively, the use of synfuels derived from hydrogen and captured carbon emissions could become a scalable option. Such synfuels require water, renewable electricity to produce hydrogen, and CO_2. Today, these power-to-liquid fuels are several times the cost of conventional kerosene, though we expect a significant cost reduction for green hydrogen (via reduced costs of renewable electricity and "electrolyzers") in the coming years. In a first step, CO_2 could be captured as waste gas from carbon-intensive industries, such as steel, chemicals, and cement.

Long term—and to become net-zero CO_2—the required CO_2 needs to be extracted from the carbon cycle (taken from the air with direct air capture). While this is costly today, the process benefits from cheaper renewable-electricity generation in the future.

While synfuels could become an answer to cutting emissions over the long run, it is unclear, at this point, which SAF sources will emerge as winners. A McKinsey analysis suggests that while current SAF costs are high in relation to kerosene cost, they will come down over time and could reach breakeven between 2030 and 2035, in an optimistic scenario (Exhibit 3).

In effect, SAF presents a classic chicken-and-egg problem. Airlines don't yet have a viable business case for buying SAF; therefore, its production volume is small, with little economies of scale and insufficient funding (Exhibit 4).

Wanted: More stakeholders for sustainable aviation fuel

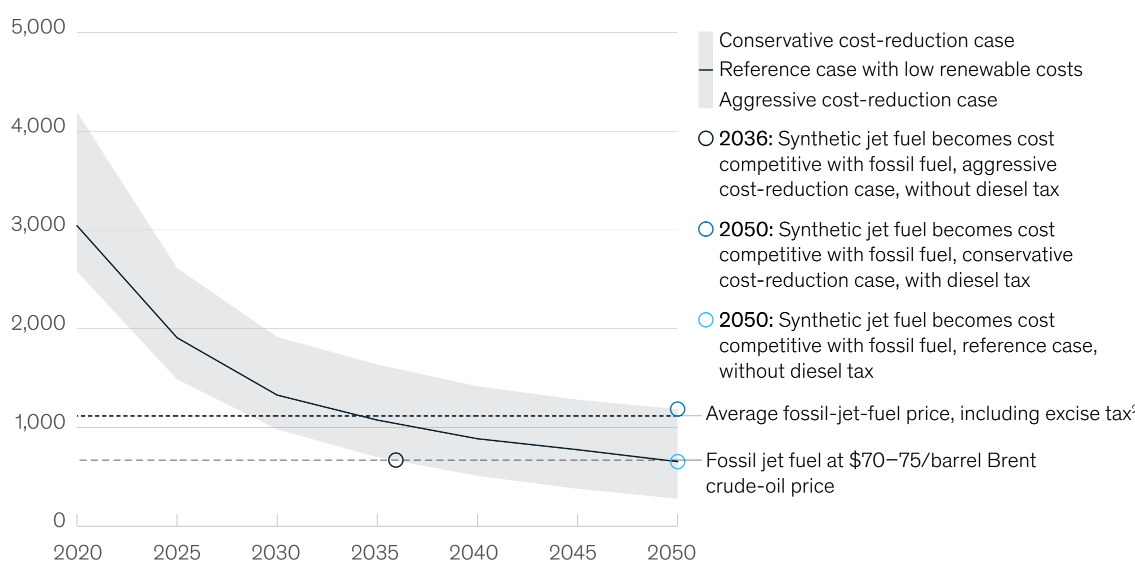
Breaking through the which-comes-first problem with SAF would involve a number of groups, each doing its part to put the puzzle together. First, airlines could build and orchestrate a consortium of stakeholders that includes technology providers and oil companies to drive demand and help bridge the cost gap. For example, airlines could commit to buying SAF at a predefined price, or at a price differential to traditional jet fuel, which would eliminate market risks for fuel suppliers.

Second, financial institutions could provide venture capital for building SAF-production facilities and new infrastructure that allows for the anticipated cost

Exhibit 3

With low renewable costs or regulation, synthetic jet fuel could become cost competitive with fossil jet fuel.

Cost of synthetic-jet-fuel production, $/metric ton, 2019[1]



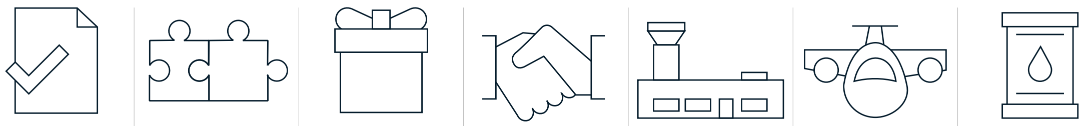
[1] Costs of synthetic fuel produced in a facility built in the corresponding year. 1 metric ton = 2,205 pounds.
[2] Assumed similar to EU diesel tax for road use ($0.50/liter).

Source: Energy Insights by McKinsey

Exhibit 4

How to overcome sustainable aviation fuel's chicken-and-egg problem.

Potential measures for spurring sustainable-aviation-fuel (SAF) production and growth



Policy and regulation	B2B contracts	B2C incentives	Demand and scale	Airports and fee structures	Prioritized aviation	Accelerated R&D
Apply effective policy measures, such as blending mandates (eg, policy in Norway)	Negotiate corporate-customer deals that involve SAF financing	Use airline-loyalty programs to incentivize customers to compensate for CO_2 through SAF	Build clusters of like-minded peers and create large-scale off-take agreements	Involve airports with suitable infrastructure and use fee structures to increase SAF uptake	Accelerate transition to alternative energy sources for road transport to make biofuels available for aviation	Motivate companies, particularly in oil and gas, to increase R&D

Ten questions airline executives should be asking

The coronavirus pandemic has created uncertainty for every industry. Airline executives should be asking themselves ten questions about what the crisis means for decarbonization and the possible responses and actions they can take:

1. Will the industry and its emissions shrink in the long run because of a fundamental shift in travel behavior?

2. Will customers become even more serious about demanding sustainable travel, with growing awareness of climate change?

3. What will governments ask in return for state support?

4. Could the coronavirus crisis lead to further industry consolidation, resulting in larger average aircraft capacity, improved seat-load factors, and improved fuel efficiency?

5. Could the crisis present an opportunity to accelerate fleet replacement or renewal?

6. How much upside is left in fuel-efficiency programs to reduce both cost and carbon emissions?

7. Could the crisis be an opportunity to harmonize air-traffic control and reduce on-the-ground and in-flight delays?

8. What does the demand shock from the coronavirus pandemic mean for CORSIA and “cap and trade” systems, such as the European Union’s Emissions Trading System?

9. What will a lasting low kerosene price mean for the economic viability of SAF?

10. Could the industry accelerate innovation—for example, into production of SAF?

savings. Building a coalition of airlines could increase the required volume, resulting in scale effects.

Third, airlines could work with B2B customers willing to pay a premium for the opportunity to decarbonize their employees' footprints. Microsoft committed to reducing its environmental footprint by promoting SAF and paying for the cost premium. For individual customers, airlines could use loyalty-program rewards as incentives to offset CO_2 through SAF use.

Fourth, policy makers at domestic and regional levels could play a critical role by creating incentives for SAF production and setting appropriate targets. Countries such as Canada and Norway that are willing to apply blending mandates are moving forward on this front. Policy makers could also reallocate aviation taxes back to the industry to fund decarbonization, closing the remaining cost gap between conventional kerosene and SAF.

The coronavirus pandemic has hit aviation hard. Yet as the industry emerges from this painful period, there is an opportunity to move closer to low-carbon goals.

The aviation industry has made great strides in fuel efficiency and operational advancements. But to reach global emission-reduction targets, it will need to move to the next level of decarbonization, and SAF is an option that could get it there. Bolder moves and much deeper collaboration among stakeholders are necessary to build financial structures and programs that can help funnel capital into SAF production.

Because the aviation industry has such long-lived assets, making decisions now is crucial. Finding solutions that bring the industry in line with global emission goals will help ensure that future generations won't feel the flight shaming of today.

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