Green Skies Ahead: A Primer on Emissions Reduction Technology in the Aviation Sector

As global aviation continues to grapple with COVID-19's negative effects on the industry, the threat of climate change still looms on the horizon. Pre-pandemic, the aviation industry accounted for about 2.5% of global emissions and stakeholders across the world—including investors, consumers, and regulators—had been urging the sector to reduce its carbon footprint. Though the pandemic has drastically cut demand and the trajectory of the global recovery remains somewhat unclear, if left unchecked, emissions from aviation are projected to grow and could even triple by 2050.[1] Global aviation, however, has been prioritizing better efficiency standards and investments in longer-term sustainable technologies to reduce the sector's carbon footprint.

In this research report, Kroll Bond Rating Agency (KBRA) provides an overview of some of the short- and long-term solutions to mitigate aviation's environmental impact, detailing current developments as well as challenges for each technology. We examine efficiency upgrades that reduce emissions, like lighter and more aerodynamic aircraft, as well as developments in the sustainable aviation fuel (SAF) market and next generation aircraft such as electric and hydrogen-powered aircraft.

International Standards

Air travel's contribution to global carbon emissions is significant, but industry participants have been increasingly focused on mitigating the sector's negative contribution to climate change. Original equipment manufacturers (OEMs), airlines, and others in the industry have a strong incentive to be proactive on emissions reduction initiatives as key stakeholders including international investors and consumers are increasingly focused on sustainability.

In 2009, the aviation industry, in tandem with the International Civil Aviation Organization (ICAO), proposed the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). CORSIA set targets for reductions in carbon dioxide (CO_2) emissions, with an aspirational industry goal of achieving carbon neutral growth starting in 2021, requiring members to offset any growth over baseline emissions. The global aviation industry has also committed to a 50% reduction in net emissions by 2050, relative to 2005 levels. Though COVID-19 has affected the timing and logistics of some of CORSIA's goals, the industry is moving forward with its plans to lower emissions. CORSIA will be implemented in three different phases, the first two of which are voluntary for CORSIA's members: a pilot phase from 2021 through 2023; the first phase from 2024 through 2026; and the second phase from 2027 through 2035.[2] As of July 2020, 88 countries and states, including the U.S., have volunteered to adopt CORSIA, representing 77% of global aviation activity.[3] Airlines have also been committing to sustainability by setting net-zero goals and prioritizing other environmental initiatives.

To achieve CORSIA's stated goals, the industry will be heavily reliant on carbon offsets and efficiency upgrades over the short term while it invests in longer-term technological developments like SAF and hydrogen-powered aircraft.

Mitigation Efforts

Efficiency and Operational Upgrades

On average, the life cycle of an aircraft is about 27.5 years, though this varies by size and model, and each new fleet generation has been approximately 15% more fuel efficient than the previous generation.[4] This is mainly due to engine improvements but also airframe and equipment upgrades such as advanced aerodynamics and enhancements in materials and structuring.[5] For example, since aircraft weight corresponds to fuel use, streamlining aircraft wing design and using thinner, lighter materials for the wings and other parts of the aircraft can decrease emissions. In the intervening periods of fleet replacement, there are smaller improvements and retrofits that airlines can perform that modestly reduce emissions as well. Interestingly, COVID-19 has hastened the retirement of older, less efficient aircraft as airlines continue to face lower demand for service.[6]

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[1] https://www.eesi.org/papers/view/fact-sheet-the-growth-in-greenhouse-gas-emissions-from-commercial-aviation
[2] https://www.icao.int/environmental-protection/CORSIA/Documents/CORSIA_FAQs_December%202020_final.pdf
[3] https://aviationbenefits.org/environmental-efficiency/climate-action/offsetting-emissions-corsia/corsia/who-volunteers-for-corsia/
[4] https://www.bts.gov/average-age-aircraft-2019
[5] https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---technology-roadmap-environment/
[6] https://www.businessinsider.com/coronavirus-havoc-forces-airlines-to-retire-iconic-planes-sooner-2020-3

Streamlining aircraft operations and using artificial intelligence to optimize flight routes can also help airlines and others reduce emissions. Some airlines have started to use a technology called Sky Breathe that analyzes data on flight paths and finds ways to save fuel. In 2019, Sky Breath helped clients save $150 million and reduce their CO_2 emissions by 590,000 tons.[7] Similarly, the U.S. Federal Aviation Authority (FAA) is working on a project called NextGen, which is an interconnected system that will improve how air traffic control communicates. NextGen will allow the FAA to schedule tighter flight landings and takeoffs, decreasing the time that planes must taxi before takeoff or circle in the air before landing, thereby reducing carbon emissions.[8]

SAF and E-Fuels

Many airlines are currently investing in and experimenting with different types of SAF. One large benefit of these fuel types is that aircraft engines do not need to be redesigned to use them and SAF can also be mixed with conventional fuels, though the blending limit varies by fuel type.

Currently, the most advanced SAF is biofuel, which is made from cooking oil, animal fat, energy crops, and food waste. But there are complications in completely replacing conventional jet fuel with biofuel. A major issue is that it is currently cost prohibitive for an airline to switch entirely to biofuel as it costs about 4x that of conventional jet fuel. From 2016 to 2020, less than 0.2% of flights worldwide used SAF. Complete replacement of jet fuel with SAF is unlikely even by 2050.

Importantly, the true emissions reductions and environmental impact of biofuel is also highly dependent on the feedstock being used. Depending on the source, biofuel can actually have a larger negative impact on the environment than conventional petroleum sources. The Swiss Federal Institute for Materials Science and Technology studied the full life cycle of biofuel types, from crop cultivation to consumption, to understand greenhouse gas (GHG) emissions and environmental impact relative to petrol, natural gas, and diesel. The study found that 21 out of 26 types of biofuels provide reductions in GHG emissions of over 30%, but almost half of the biofuel types have a larger negative environmental impact than petroleum fuels due to the required land use, cultivation techniques, negative impacts on surrounding ecosystems, and other issues. The biofuels with little to no reductions in GHG emissions and a higher environmental impact than conventional fuel sources include biofuel made from potatoes, rye, and soy.[9] Therefore, airlines and others in the industry will need to continue to focus on biofuels' emissions reductions and environmental impact when deciding on a replacement fuel source.

E-fuel, also called synthetic fuel or power-to-liquid fuel, is another promising SAF technology but is still in the very early stages of development and will not be widely available anytime soon. E-fuel uses energy (which needs to come from renewable sources if emissions reductions is the goal) to split water into hydrogen and oxygen in a process called electrolysis. The hydrogen is then combined with carbon monoxide created from captured CO_2, which creates fuel. As this fuel process is incredibly energy intensive, clean energy prices will need to continue to drop dramatically for the process to be considered a cost-effective option.

Next Generation Aircraft

Many companies are experimenting with zero-emission electric and hydrogen-powered airplanes. Though promising, these technologies, like SAF, are a long-term solution that will not be widely available for years to come.

Aircraft can be powered by hydrogen in two ways: through hydrogen fuel cells or hydrogen combustion. Hydrogen combustion works in the same way as conventional internal combustion, where hydrogen (liquid or gas) replaces conventional fuel, requiring relatively few changes to current engines.[10] Aircraft powered by hydrogen fuel cells convert energy from molecules into electrical energy by combining hydrogen with oxygen and producing an electric current.[11] The challenge with utilizing hydrogen as an aircraft fuel is, although hydrogen has 3x the amount of energy per kilogram compared with conventional jet fuel, it is much lighter than jet fuel. This means that hydrogen storage tanks must be 3x larger than for conventional jet fuel. Hydrogen must also be stored at a temperature of -253°C, which could prove challenging as well.[12] Additionally, hydrogen is a highly combustible element, meaning that many safety concerns will need to be resolved in the process of development.

Fully electric airplanes are also being tested and are showing promise, especially for short-haul flights, but battery storage has proved difficult. A battery's ability to hold power is measured in "specific energy," which is energy per unit mass. Jet

[7] https://www.nationalgeographic.com/travel/article/greener-air-travel-will-depend-on-these-emerging-technologies#close
[8] https://www.nationalgeographic.com/travel/article/greener-air-travel-will-depend-on-these-emerging-technologies#close
[9] https://ec.europa.eu/environment/integration/research/newsalert/pdf/1si1_en.pdf
[10] https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---technology-roadmap-environment/
[11] https://www.airbus.com/newsroom/stories/Is-this-the-next-clean-energy-to-power-aviation.html
[12] https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---technology-roadmap-environment/

fuel's specific energy is almost 12,000 watt-hours per kilogram, while even the most efficient batteries on the market today have a specific energy of approximately 250 watt-hours per kilogram.[13] This means that the batteries currently needed to power a plane, particularly larger airplanes with longer flight durations, would be too large and heavy for the aircraft. The first commercial, all-electric flights will likely be in smaller planes with trips limited to a few hundred miles.

Credit Implications and Conclusion

When rating an issuer, KBRA engages directly with issuer management teams to examine their strategy for mitigating or capitalizing on the ESG risks and opportunities they face. As there is rising pressure from global stakeholders, namely investors and consumers, most aviation companies including OEMs, airlines, and aircraft lessors, are actively investing in making their companies and operations more sustainable. Companies that ignore environmental issues that are deemed a priority by society may face backlash from their stakeholders, which can negatively affect revenues and access to capital and, ultimately, creditworthiness. Most OEMs and airlines, as key stakeholders, have been proactive in reducing their operational footprint but also in making new aircraft as energy efficient as possible, advocating for better air traffic management systems, and investing in the SAF market to make sustainable fuel more widely available, which KBRA views favorably. Aircraft lessors are also important to reducing the industry's carbon footprint. As owners, but not operators of aircraft, lessors play a role in creating incentives for their customers (airlines) as well as influencing sustainability discussions with OEMs. In addition, there are many other service providers and suppliers to the aviation industry who may have a direct or indirect role in mitigating ESG risk exposure related to aviation.

Over the longer term, aircraft lessors (which own close to half of the global aircraft fleet) and airlines—as their key customers—will need to continue to help facilitate emissions reduction schemes. OEMs will also play a critical role in advancing zero emission technology such as electric and hydrogen aircraft, which have the highest promise for reducing global emissions over the longer term. However, because of the huge amount of capital needed for technological development, public policy initiatives will also need to be part of the solution. Even as the industry continues to invest millions of dollars each year in mitigating aviation's negative effect on climate change, subsidies, taxes, and other incentives will most likely be necessary for aviation to fully transition to a low carbon future.

[13] https://www.businessinsider.com/electric-planes-future-of-aviation-problems-regulations-2020-3

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