LCRI LOW-CARBON RESOURCES INITIATIVE

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EXECUTIVE SUMMARY

ASSESSMENT OF LOW-CARBON FUEL PATHWAYS FOR AVIATION

The energy consumption and greenhouse gas (GHG) emissions resulting from air travel have been growing steadily over the past several years, and, in 2019, commercial airlines carried about 4.5 billion passengers systemwide.[1] The sector's carbon emissions amounted to over 915 million metric tons of CO_2 in 2019, which accounts for around 2% of global annual GHG emissions.[1] In 2010, the International Civil Aviation Organization, the United Nations body that governs civil aviation, set a goal of carbon-neutral growth starting in 2020. Airlines accounting for around half of the commercial aviation sector's 2019 emissions have set goals to reach net-zero emissions by 2050,[2] and, in October 2021, the International Air Transport Association, whose 290 member airlines carry more than 80% of the world's air traffic, introduced a 2050 net-zero carbon emissions target. There is broad interest and commitment in reducing CO_2 emissions from aviation sources.

While technical and operational measures to increase fuel efficiency are expected to drive near-term emissions reductions, achieving deep decarbonization of the sector to reach ambitious 2050 net-zero goals will require a large-scale transition to low-carbon fuels and energy sources.

Key insights from the full report include:

- Airline carriers have improved fuel efficiency and thus reduced energy intensity for aircraft usage over recent years; however, due to increasing demand for air travel, passenger aircraft CO_2 emissions increased 33% between 2013 and 2019, despite these efficiency improvements.[3] Due to a slowing pace of energy efficiency improvements in recent years and anticipated continuing demand growth, powering commercial aircraft fleets sustainably in the coming decade will require a shift from the industry's existing fossil fuel-based model.
- The primary low-carbon fuels under consideration by the aviation industry as replacements for conventional jet fuels are sustainable aviation fuels (SAF) and hydrogen. These alternative fuels are expected to play a key role in meeting the industry's aspirational 2050 GHG reduction target.
- SAF offer a significant near-term opportunity for reducing aviation sector emissions. They are already approved as a fuel blended with conventional jet fuel, with the blend percentages varying from 5% up to 50%. These fuels are produced from renewable biomass, waste resources, and via Power-to-Liquid (PtL) production pathways. SAF were first introduced in 2008 and have been used successfully on over 375,000 commercial flights globally.[4]
- Hydrogen's application as a low-carbon, alternative fuel for commercial aircraft is an active and ongoing area of research, particularly for short distance flights. Commercial operations of hydrogen-fueled passenger aircraft are expected within 5 to 15 years. The different propulsion technology approaches for hydrogen-powered aviation include fuel cells, hybrid fuel cell-engine systems, and turbine engines.

[1] Air Transport Action Group (ATAG), "Facts and Figures." https://www.atag.org/facts-figures.html.

[2] B. Graver, "Glass Half Full: An Invitation for IATA to Update Climate Goals," The International Council on Clean Transportation. Posted April 6, 2021. https://theicct.org/blog/staff/iata-update-apr2021.

[3] B. Graver, D. Rutherford, and S. Zheng, "CO_2 Emissions from Commercial Aviation: 2013, 2018, and 2019," The International Council on Clean Transportation. October 2020. https://theicct.org/publications/co2-emissions-commercial-aviation-2020.

[4] Aviation Benefits Beyond Borders, "Sustainable Aviation Fuel." Last updated November 15, 2021. https://aviationbenefits.org/environmental-efficiency/climate-action/sustainable-aviation-fuel/.

- Utilization of battery-powered electric motors to power passenger aircraft has reached early commercialization stage, mostly for small, non-commercial aircraft. There are at least 14 different commercial electric aircraft models that are expected to be made available by 2030, including seaplanes, vertical takeoff and landing aircraft, and Cessnas. However, the relatively low energy density and power capacity of batteries, even when accounting for anticipated advancements in battery technologies, will likely limit all-electric aviation to smaller aircraft operating on short-haul and some medium-haul routes by mid-century.
- Airport ground support equipment manufacturers and operators are exploring and beginning to adopt alternative energy sources for ground support equipment, which includes hydrogen fuel cell and electric units. Ground support equipment is expected to be a key near-term opportunity for GHG emissions reductions in the aviation industry.
- Likely decisive factors in low-carbon fuel selection for aircraft include relative volumetric energy densities, safety, reliability, storage and handling requirements, availability/scalability, infrastructure adaptation costs, and fuel price. Fuel price is a critical factor because of the airlines' narrow profit margins. Additional R&D is also required for determination of the life-cycle carbon emission reduction potential of low-carbon aviation fuels, particularly SAF, that account for indirect or unintentional emissions impacts associated with feedstock production.
- With increasing attention toward decarbonization of the aviation sector, setting up a public policy around this topic is becoming a priority in both the United States and European Union (EU). Norway became the first country to introduce an SAF obligation, and Germany, Sweden, the Netherlands, France, and Spain are considering similar policies. Regulatory incentives for the adoption of hydrogen in the sector are currently at a much more fledgling stage but are gradually gaining attention.

The full report provides an overview of available emission reduction pathways for the aviation transport sector and characterizes the landscape of key low-carbon fuel candidates, including their relative competitiveness, applicability, development statuses, and research gaps.

The Low-Carbon Resources Initiative

This executive summary was published under the Low-Carbon Resources Initiative (LCRI), a joint effort of the Electric Power Research Institute (EPRI) and Gas Technology Institute (GTI) addressing the need to accelerate development and deployment of low- and zero-carbon energy technologies. The LCRI is targeting advances in the production, distribution, and application of low-carbon energy carriers and the cross-cutting technologies that enable their integration at scale. These energy carriers, which include hydrogen, ammonia, synthetic fuels, and biofuels, are needed to enable affordable pathways to economy-wide decarbonization by mid-century. For more information, visit www.LowCarbonLCRI.com.

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