REPORT IN BRIEF

Aeronautics and Space Engineering Board

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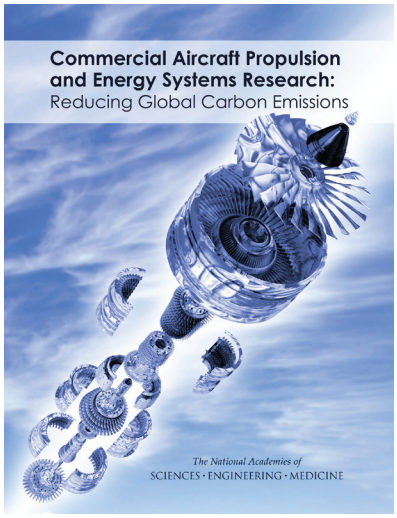
DIVISION ON ENGINEERING AND PHYSICAL SCIENCES

Commercial Aircraft Propulsion and Energy Systems Research: Reducing Global Carbon Emissions



At the request of the National Aeronautics and Space Administration (NASA), the National Academies of Sciences, Engineering, and Medicine convened a committee to develop a national research agenda for reducing carbon dioxide (CO_2) emissions from commercial aviation. The report focuses on propulsion and energy technologies for reducing carbon emissions from large, commercial aircraft—single-aisle and twin-aisle aircraft that carry 100 or more passengers—because such aircraft account for more than 90 percent of global emissions from commercial aircraft. Moreover, while smaller aircraft also emit CO_2, they make only a minor contribution to global emissions, and many technologies that reduce CO_2 emissions for large aircraft also apply to smaller aircraft. Excluding from consideration other research areas such as air traffic management systems and policy approaches such as carbon taxes, the committee identified 12 high-priority research projects[1] divided among four key topics related to propulsion and energy technologies.

RECOMMENDATION: *High-Priority Approaches*. Agencies and organizations in government, industry, and academia with an interest in developing propulsion and energy system technologies that could reduce CO_2 emissions from global civil aviation and that could be introduced into service during the next 10 to 30 years should execute a national research agenda that places the highest priority on four approaches:

- Advances in aircraft–propulsion integration,
- Improvements in gas turbine engines,
- Development of turboelectric propulsion systems, and
- Advances in sustainable alternative jet fuels.

AIRCRAFT-PROPULSION INTEGRATION

Advances in aircraft–propulsion integration are needed to support low-carbon innovations that are not achievable by discrete improvements to individual component technologies. This includes developing lighter, more efficient nacelles to increase propulsion efficiency for standard aircraft as well as nonstandard configurations that require a much higher level of propulsion–aircraft integration to enable boundary layer ingestion.

High-Priority Research Projects

- Nacelles for Ultrahigh Bypass Ratio Gas Turbines
- Boundary Layer Ingestion (BLI)

[1]*While the committee identified some of the most promising approaches that could be successfully implemented in the next 30 years, only time will tell which technological breakthroughs will prove most effective. By putting forward a set of research priorities, the committee is not recommending that all research to support other technologies be discontinued.*

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GAS TURBINE ENGINES

Gas turbine engines have considerable room for improvement, with a potential to reach overall efficiencies 30 percent greater than the best engines in service today. This magnitude of gain requires investment in a host of technologies such as developing advanced materials to reduce weight and improve engine performance and designing smaller, more efficient engine cores.

High-Priority Research Projects

- Low Pressure-Ratio Fan Propulsors
- Engine Materials and Coatings
- Small Engine Cores

TURBOELECTRIC PROPULSION

Turboelectric systems are electric propulsion systems that use gas turbines to drive the electrical generators that power electric motors, which in turn drive propulsors (fans or propellers). These systems are probably the only approach for developing electric propulsion systems for a large passenger aircraft that can be feasibly achieved in the next 30 years. Combined with other technologies, turboelectric systems could potentially reduce fuel burn by up to 20 percent or more compared to aircraft in service today. These projects would include research to better understand the benefits and design tradeoffs related to key aircraft systems and the creation of system research facilities to better develop the core megawatt-class technologies for turboelectric aircraft propulsion systems.

High-Priority Research Projects

- Turboelectric Aircraft Systems Studies
- Core Turboelectric Technologies
- Megawatt-Class Research Facilities

SUSTAINABLE ALTERNATIVE JET FUELS (SAJF)

This report uses SAJF to describe drop-in replacements for conventional jet fuel that meet current jet fuel specifications either on their own or when blended with conventional jet fuel. SAJF would be produced primarily from nonpetroleum sources and have the potential to immediately lower the net global CO_2 emissions from commercial aviation. As drop-in fuels, SAJF are compatible with existing aircraft and infrastructure, so their widespread use would not be limited by the time it takes for a new technology to slowly propagate through an aviation fleet. SAJF research projects would include detailed evaluations of the benefits of SAJF, developing sustainable and low-cost feedstocks, determining the most cost-effective conversion technologies for full-scale fuel production from these feedstocks, and fuel testing and qualification for commercialization.

High-Priority Research Projects

- SAJF Industry Modeling and Analysis
- Low-Cost Feedstocks
- Conversion Processes, Fuel Production, and Scale-up
- SAJF Fuel Testing, Qualification, and Certification

CHALLENGES AND NEXT STEPS

The technical, economic, and policy challenges facing each of the high-priority approaches are detailed in this report. In addition, two systemic challenges apply to all four of the approaches:

- Commercial aviation is a highly competitive industry for which reduction in fuel burn (and, thus, CO_2) is a major technology driver. Cost considerations can be a challenge and have to be taken into account as new systems are proposed for commercial development.
- Commercial aircraft are composed of many distinct systems that are carefully integrated and regulated to maximize performance and safety. Disciplined system integration is required to introduce new technologies so that the improvement of one system does not adversely impact the performance of other systems or the performance of the aircraft as a whole.

Developing new technology for large commercial aircraft requires substantial time and resources, and it will not be possible to execute the recommended research agenda without the continued efforts of and coordination among federal agencies, industry, and academia. These entities can each play an important role in reducing CO_2 emissions by focusing their efforts on the projects that best align with their own organizational objectives and expertise.

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