

Sustainable Aviation

A holistic, partnering-enabled strategy to decarbonize the aviation industry

New technologies are changing the future of aviation, providing actionable pathways for lowering greenhouse gas emissions in a sector that is among the most difficult to decarbonize.

The National Renewable Energy Laboratory (NREL) is developing public and private partnerships to accelerate this evolution with critical research, analysis, modeling, and validation expertise in energy carriers, aircraft components, and airport infrastructure. Our solutions will not only permanently lower the carbon intensity of flight, but fundamentally improve the carbon intensity, mobility, and resiliency of the entire aviation ecosystem.

In support of this vision, NREL has instituted a comprehensive, coordinated sustainable aviation strategy that paves the way for research, development, demonstration, and deployment, leading to solutions for decarbonizing aviation.

Cross-Sector Collaboration Can Address Climate Challenges and Meet Industry Goals Alike

Amid rising demand for air travel, aviation companies seek solutions to achieve environmental goals while continuing to provide the safe, high-quality service consumers demand at a reasonable cost. The United States and other governments are also investing heavily in emerging energy pathways to achieve net-zero greenhouse gas emissions by 2050 in line with global climate commitments.

Achieving a sustainable aviation future demands a network of stakeholders working in good faith to identify, develop, and deliver holistic, sustainable energy solutions. In this way, cross-sector collaborations can do more than solve critical climate challenges. They unite interests and expertise to invent powerful solutions that empower a diversity of stakeholders: commercial airlines, airports, technology companies, energy firms, utilities, equipment manufacturers, trade groups, governmental agencies, and more.

By working together toward a common goal, the entire network stands to benefit through:

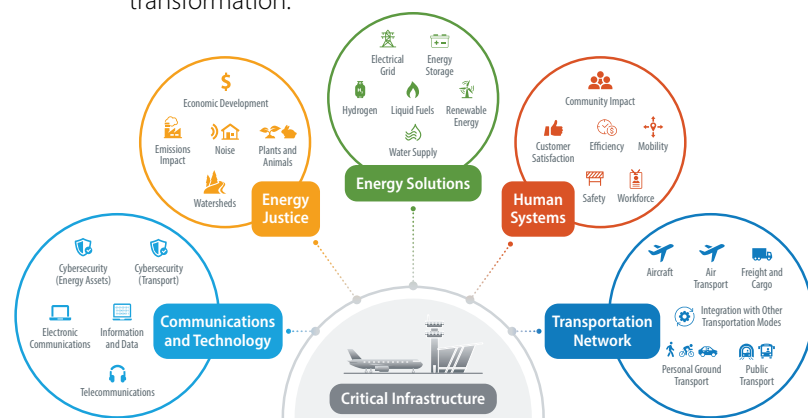
- Accelerating technical progress and aligning efforts across industry silos that develop impactful solutions
- Developing industry standards and best practices
- Addressing system interdependencies via holistic analysis.

Nurturing the Entire Aviation Ecosystem

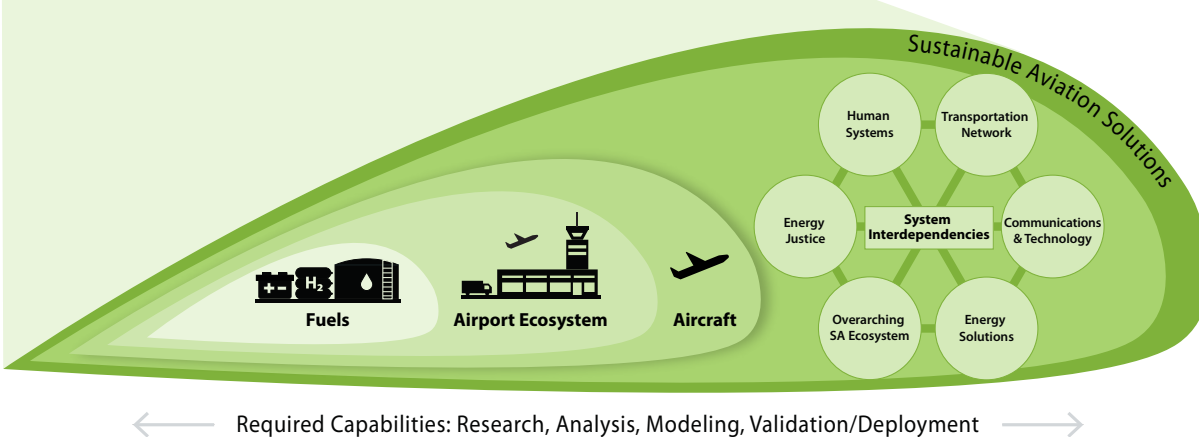
Making aviation sustainable also hinges on a deep understanding of the social, economic, technological, geographical, and environmental influences that shape the industry. Such awareness is critical to success—informing investments, guiding research, framing analysis, and prioritizing deployment.

Considering the sheer complexity of this system, NREL's sustainable aviation strategy is:

- **Holistic:** We focus on evaluating and employing holistic approaches that prioritize safe and efficient transport of goods and passengers while recognizing the impacts on communities and the related system.
- **Targeted:** We work with industry partners to identify critical needs that will achieve deep decarbonization, creating targeted solutions for overcoming the biggest barriers to realize low- or net-zero-carbon aviation.
- **Collaborative:** We work together toward shared priorities to achieve strategic alignment that will drive a clean energy transformation.



NREL's strategy takes a holistic view, considering the complex vectors that influence the sustainable aviation ecosystem.



NREL Capabilities Address All Energy Aspects of Aviation Decarbonization

NREL is uniquely positioned to deliver decarbonization solutions that address all energy aspects of the aviation ecosystem. Through strong relationships with a growing network of partners and stakeholders, NREL is already developing and implementing solutions that can be scaled globally—from net-zero-carbon energy sources to infrastructure optimization and aircraft propulsion technologies.

Low- and Net-Zero-Carbon Fuels and Energy Carriers

NREL offers end-to-end expertise on developing and demonstrating low- and net-zero-carbon fuels—from field to fuel, electron to molecule, and bench to pilot scales.

NREL Expertise:

- Sustainable aviation fuel (SAF) production pathways from biomass, carbon dioxide (CO₂), and waste (thermochemical, biological, hybrid, and electrochemical pathways)
- Techno-economic and life cycle analysis (micro- and macro-level)
- SAF utilization and ASTM qualification
- Molecular simulation and structure–property relationships
- SAF supply chain logistics
- E-fuels scaling (liquid fuels from hydrogen and CO₂)
- Green hydrogen production
- Hydrogen infrastructure analysis.

Integrated, Decarbonized Ground Infrastructure

NREL analysis and modeling can decarbonize airports, military bases, and vertiports to seamlessly integrate them with ground-based transportation systems.

NREL Expertise:

- Intermodal mobility demand modeling
- Infrastructure analysis (campuses, buildings, terminals, and air- and land-side transportation networks)

- Techno-economic deployment optimization
- Energy source/generation resiliency
- Grid-interactive and efficient buildings
- Electric vehicle integration (smart charging and load management)
- Digital twins
- Project de-risking
- Behind-the-meter storage
- Hydrogen production, storage, and delivery
- Energy and environmental justice analysis
- Energy storage.

Sustainable Aircraft of the Future

Aircraft of the future will transcend the one-size-fits-all approach of today's liquid-fueled aircraft. NREL develops systems and components that enable these new fuel types and propulsion pathways.

NREL Expertise:

- Power electronics, including electrical, thermal, mechanical, and reliability aspects and modeling, fabrication, and characterization
- Electrochemical and thermal energy storage, including diagnostics, safety, thermal management, and materials
- Fuel cell reliability and aviation-related capabilities
- Hydrogen fuel storage.

JOIN THE EFFORT

NREL is establishing public and private partnerships to accelerate the transition to net-zero aviation. Tap world-class capabilities, leading expertise, and strategic partners—and make your mark on the sustainable aviation future.

Contact NREL Strategic Partnerships Manager Brett Oakleaf at brett.oakleaf@nrel.gov to learn more.