Environment & Energy Research & Development Portfolio Overview

Prepared for: CLEEN Consortium Meeting

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Office of Environment and Energy
Federal Aviation Administration

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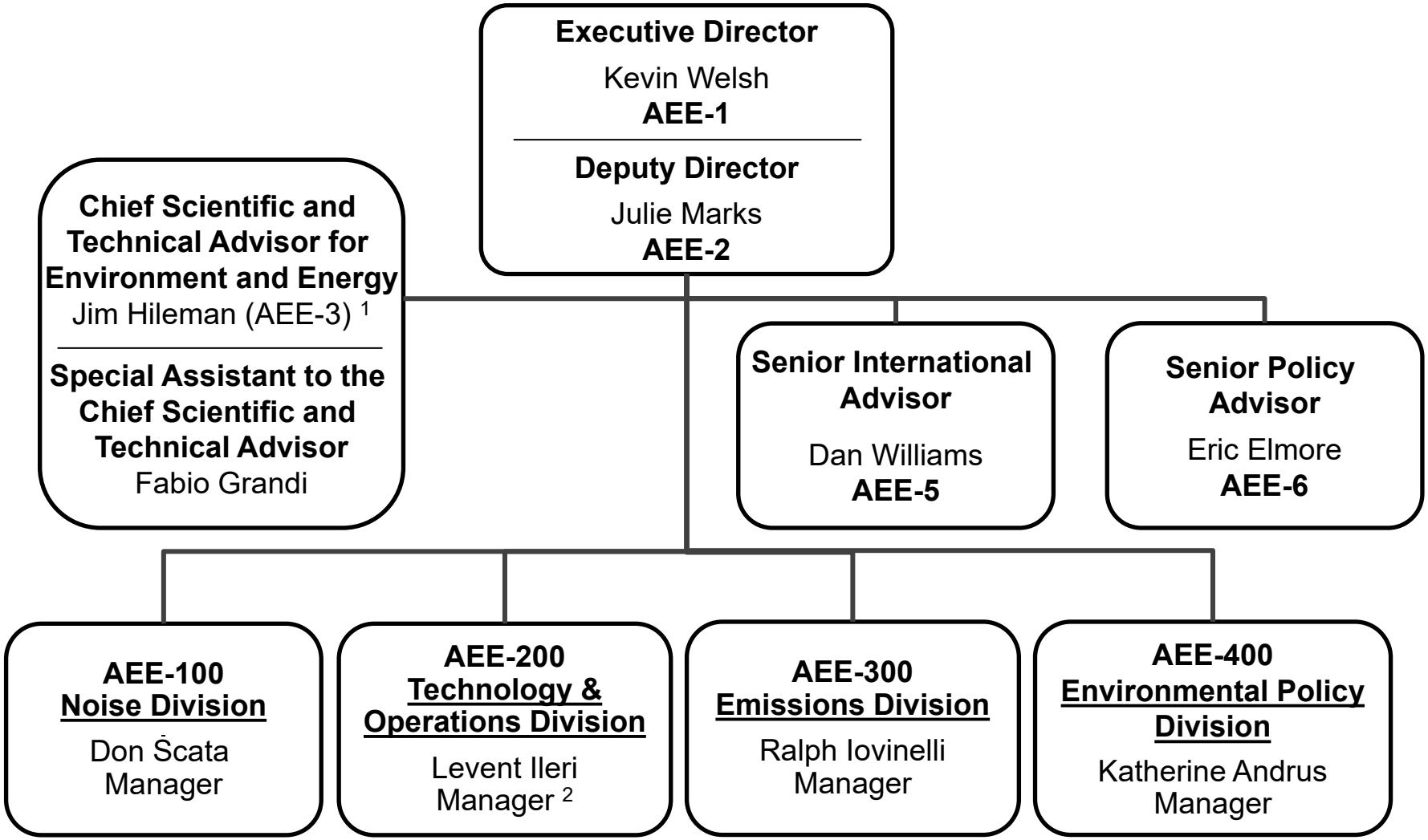
Presentation Outline

- **Office of Environment and Energy – Background & E&E Overview**
- **Aviation Climate Action Plan**
- **FY2023 Budget**
- **Summary**

AEE Organizational Structure



[1] ASCENT Program Manager, as a subset of his Chief Scientist duties

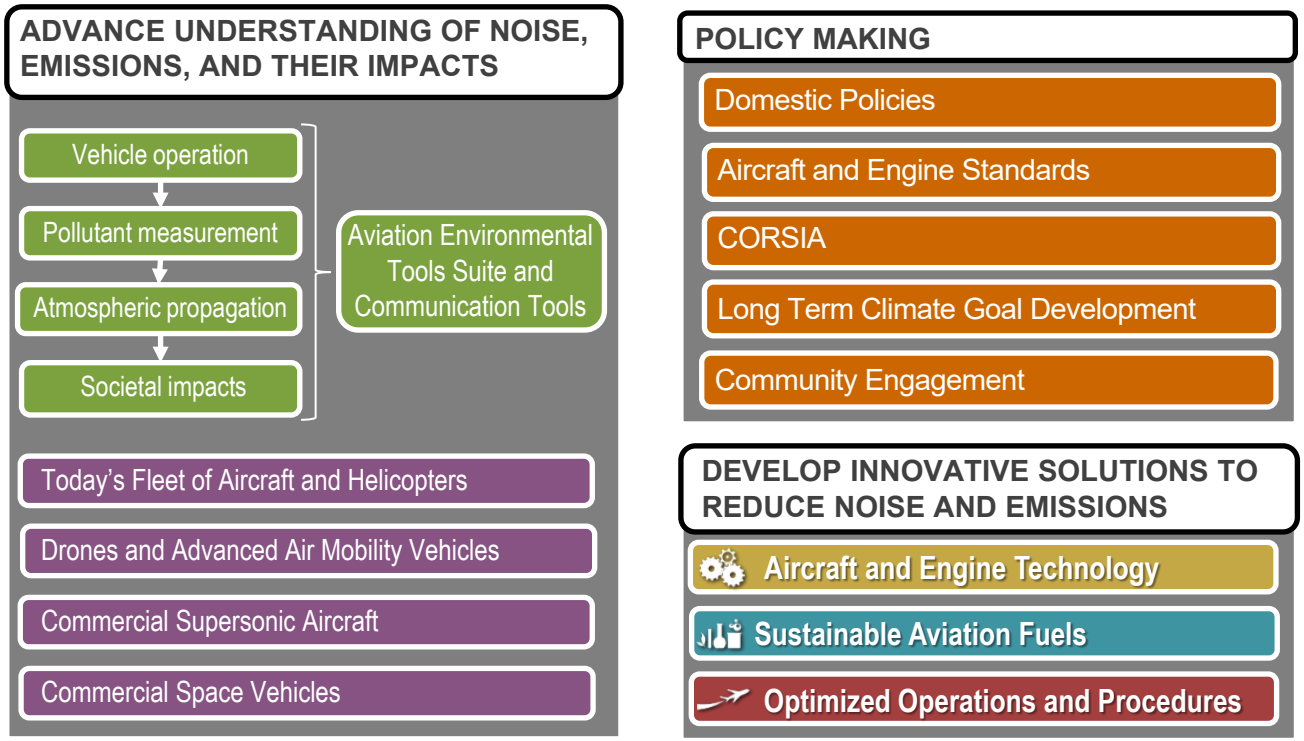
[2] CLEEN Program Manager, as a subset of his Division Manager duties

Environmental & Energy (E&E) Strategy

E&E Mission: *To understand, manage, and reduce the environmental impacts of global aviation through research, technological innovation, policy, and outreach to benefit the public*

E&E Vision: *Remove environmental constraints on aviation growth by achieving quiet, clean, and efficient air transportation*

E&E Program:



ASCENT AVIATION SUSTAINABILITY CENTER
www.ascent.aero/

Continuous Lower Energy, Emissions & Noise CLEEN Federal Aviation Administration
www.faa.gov/go/cleen/

CAAFI®
www.caafi.org/

the VOLPE center

ASCENT Center of Excellence

For 18 years, FAA Office of Environment and Energy has relied on university centers of excellence to:

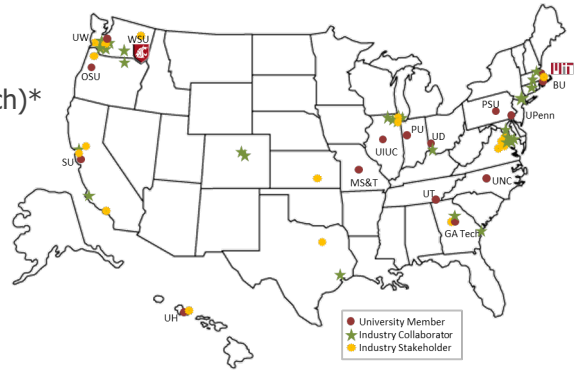
- Provide knowledge to inform decision making on environment and energy matters;
- Enable the introduction of innovative solutions to cost-effectively mitigate the environmental impacts of aviation; and
- Support the instruction of hundreds of professionals with knowledge of the environmental challenges facing aviation (*674 students supported and counting*).

ASCENT Research Portfolio

- In 2013, FAA established ASCENT to conduct research on environment and alternative jet fuels
- Portfolio covers broad range of topics on Alternative Jet Fuels, Emissions, Noise, Operations, and Analytical Tools
- Over 80 research projects with over $15M annual budget

Lead Universities:
Washington State University (WSU)
Massachusetts Institute of Technology (MIT)*

Core Universities:
Boston University (BU)*
Georgia Institute of Technology (Ga Tech)*
Missouri University of Science and Technology (MS&T)*
Oregon State University (OSU)
Pennsylvania State University (PSU)*
Purdue University (PU)*
Stanford University (SU)*
University of Dayton (UD)
University of Hawaii (UH)
University of Illinois at Urbana-Champaign (UIUC)*
University of North Carolina at Chapel Hill (UNC)*
University of Pennsylvania (UPenn)*
University of Tennessee (UT)
University of Washington (UW)



Multiple international partners

Advisory Committee (57 orgs)
5 airports
4 airlines
9 NGO/advocacy
8 aviation manufacturers
10 feedstock/fuel manufacturers
21 R&D, service to aviation sector

ASCENT Support

Federal Aviation Administration
Transport Canada
NASA
Environmental Protection Agency
Defense Logistics Agency - Energy
U.S. Dep't of Energy
U.S. Dep't of Agriculture
Air Force Research Laboratory

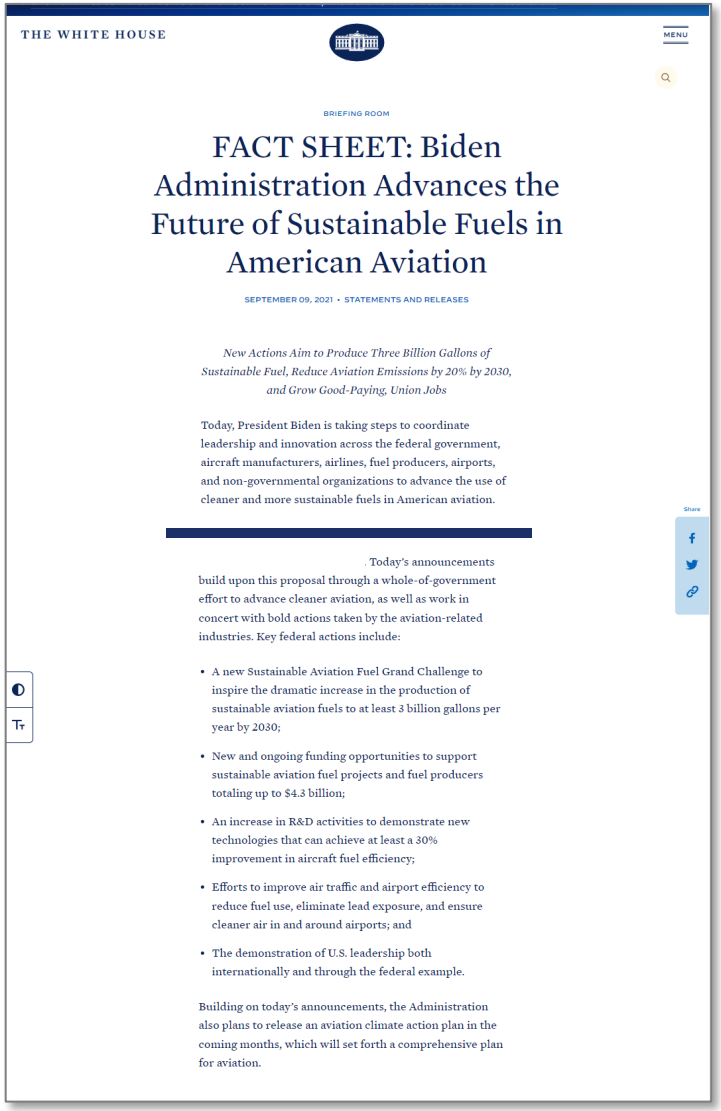
White House Sustainable Aviation Event

On September 9, 2021, government and industry leaders met to discuss actions and make new announcements regarding efforts to address aviation and climate change in the near-term, with a view to long-term ambition.

Key federal actions include:

- A new Sustainable Aviation Fuel Grand Challenge to inspire the dramatic increase in the production of sustainable aviation fuels to at least 3 billion gallons per year by 2030;
- An increase in R&D activities to demonstrate new technologies that can achieve at least a 30% improvement in aircraft fuel efficiency;
- Efforts to improve air traffic and airport efficiency to reduce fuel use, eliminate lead exposure, and ensure cleaner air in and around airports; and
- The demonstration of U.S. leadership both internationally and through the federal example.

"…the Administration also plans to release an aviation climate action plan in the coming months, which will set forth a comprehensive plan for aviation."



THE WHITE HOUSE

MENU

BRIEFING ROOM

FACT SHEET: Biden Administration Advances the Future of Sustainable Fuels in American Aviation

SEPTEMBER 09, 2021 • STATEMENTS AND RELEASES

New Actions Aim to Produce Three Billion Gallons of Sustainable Fuel, Reduce Aviation Emissions by 20% by 2030, and Grow Good-Paying, Union Jobs

Today, President Biden is taking steps to coordinate leadership and innovation across the federal government, aircraft manufacturers, airlines, fuel producers, airports, and non-governmental organizations to advance the use of cleaner and more sustainable fuels in American aviation.

Today's announcements build upon this proposal through a whole-of-government effort to advance cleaner aviation, as well as work in concert with bold actions taken by the aviation-related industries. Key federal actions include:

- A new Sustainable Aviation Fuel Grand Challenge to inspire the dramatic increase in the production of sustainable aviation fuels to at least 3 billion gallons per year by 2030;
- New and ongoing funding opportunities to support sustainable aviation fuel projects and fuel producers totaling up to $4.3 billion;
- An increase in R&D activities to demonstrate new technologies that can achieve at least a 30% improvement in aircraft fuel efficiency;
- Efforts to improve air traffic and airport efficiency to reduce fuel use, eliminate lead exposure, and ensure cleaner air in and around airports; and
- The demonstration of U.S. leadership both internationally and through the federal example.

Building on today's announcements, the Administration also plans to release an aviation climate action plan in the coming months, which will set forth a comprehensive plan for aviation.

White House Sustainable Aviation Fact Sheet:
https://www.whitehouse.gov/briefing-room/statements-releases/2021/09/09/fact-sheet-biden-administration-advances-the-future-of-sustainable-fuels-in-american-aviation/

Federal Aviation Administration

Aviation Climate Action Plan

- International Civil Aviation Organization (ICAO) – “State Action Plans”
- Plan builds on ongoing FAA Environment & Energy Program – long-term focus on reducing climate impacts of aviation
- Administration focus on climate – Achieving net zero emissions economy-wide by 2050

- Climate Action Plan Press Release: https://www.faa.gov/newsroom/us-releases-first-ever-comprehensive-aviation-climate-action-plan-achieve-net-zero
- Climate Action Plan Document: https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf

U.S. Aviation Climate Goal

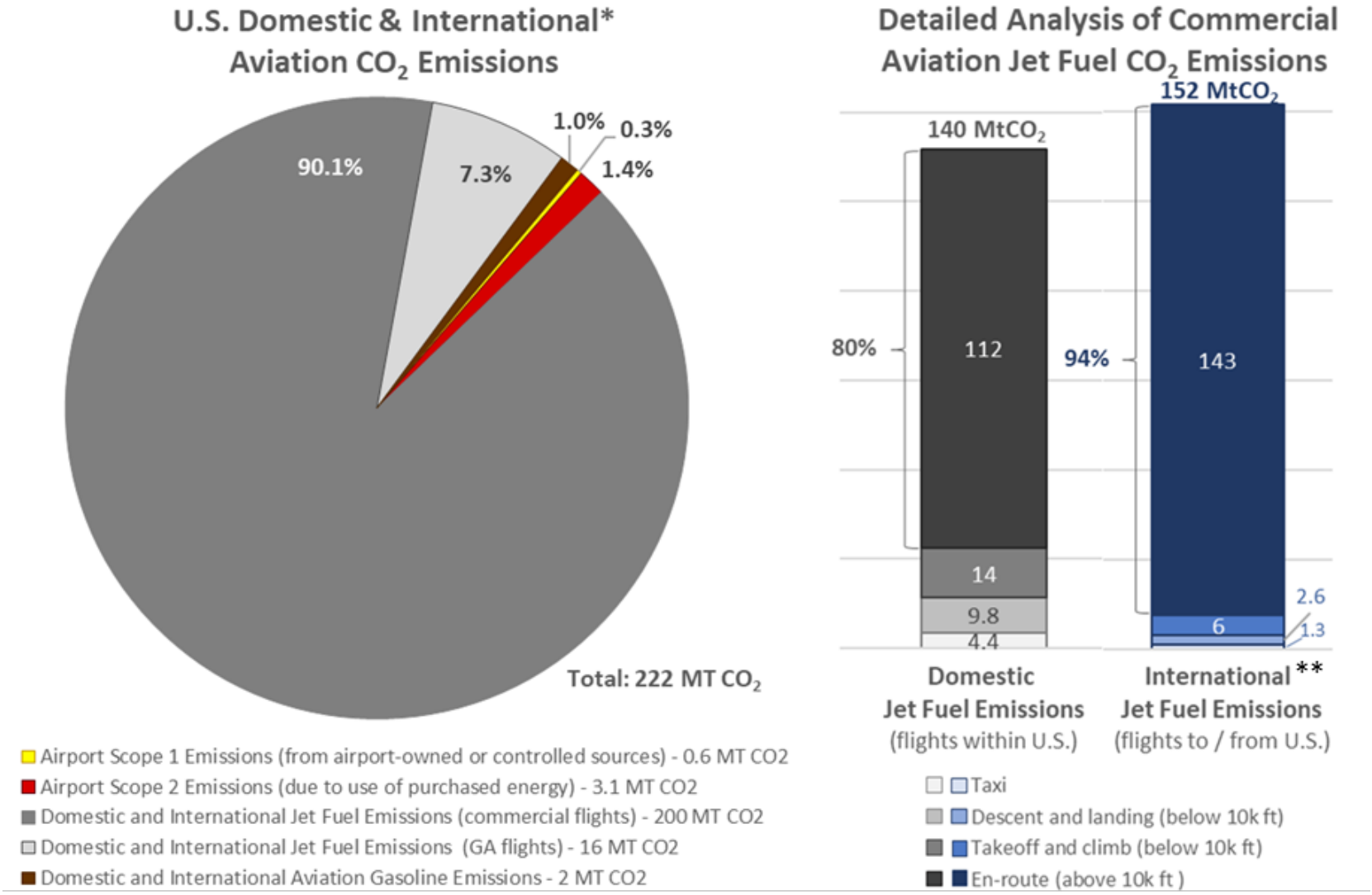
To be effective, a goal should be clear, achievable, and ambitious with specific actions that can be taken to achieve it. The goal outlined below contributes to the broader objective to achieve net-zero GHG emissions economy-wide by 2050.

U.S. Aviation Climate Goal:
Net-Zero GHG Emissions* from U.S. Aviation Sector** by 2050

* Aviation GHG emissions include life cycle carbon dioxide (CO_2), nitrous oxide (N_2O), and methane (CH_4) emissions. Aircraft engines produce negligible amounts of nitrous oxides and methane, so this plan has a focus on aviation combustion CO_2 emissions and well-to-tank life cycle GHG emissions (CO_2, N_2O, and CH_4). The U.S. Aviation 2050 Goal is based on emissions that are measurable and currently monitored. Research is ongoing into the climate impacts of aviation-induced cloudiness and the indirect climate impacts of aviation combustion emissions (see section 7 for details on the climate impacts of aviation non-CO_2 combustion emissions).

** This U.S. aviation goal encompasses CO_2 emissions from (1) domestic aviation (i.e., flights departing and arriving within the United States and its territories) from U.S. and foreign operators, (2) international aviation (i.e., flights between two different ICAO Member States) from U.S. operators, and (3) airports located in the United States.

Analysis of U.S. Aviation CO_2 Emissions in 2019



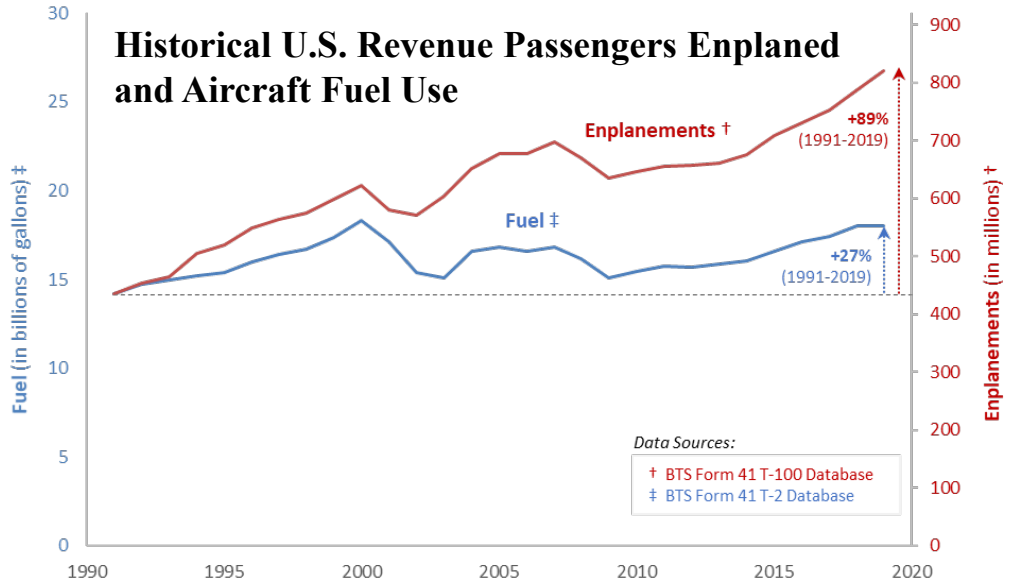
* CO_2 emissions from (1) domestic aviation (i.e., flights departing and arriving within the United States and its territories) from U.S. and foreign operators and (2) international aviation (i.e., flights between two different ICAO Member States) from U.S. operators (only). Airport scopes 1 and 2 added for this specific analysis (figure).

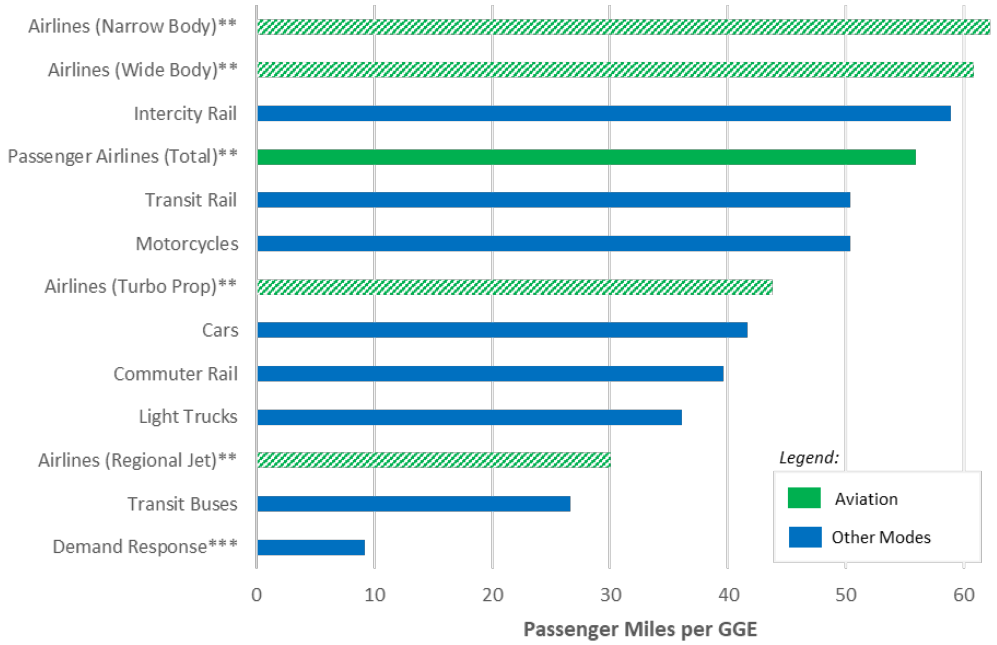
** International aviation to / from the United States, regardless of the operator of the flights i.e., including both U.S. and foreign operators.

Domestic Fuel Efficiency

National Airspace System (NAS) is operating much more efficiently today than 30 years ago —moving more passengers on the same amount of energy.

Today's fleet of aircraft has an average fuel efficiency of 57.5 passenger-miles per gallon of fuel; for comparison, a modern Toyota Prius hybrid has a fuel economy of 54 miles per gallon (MPG).

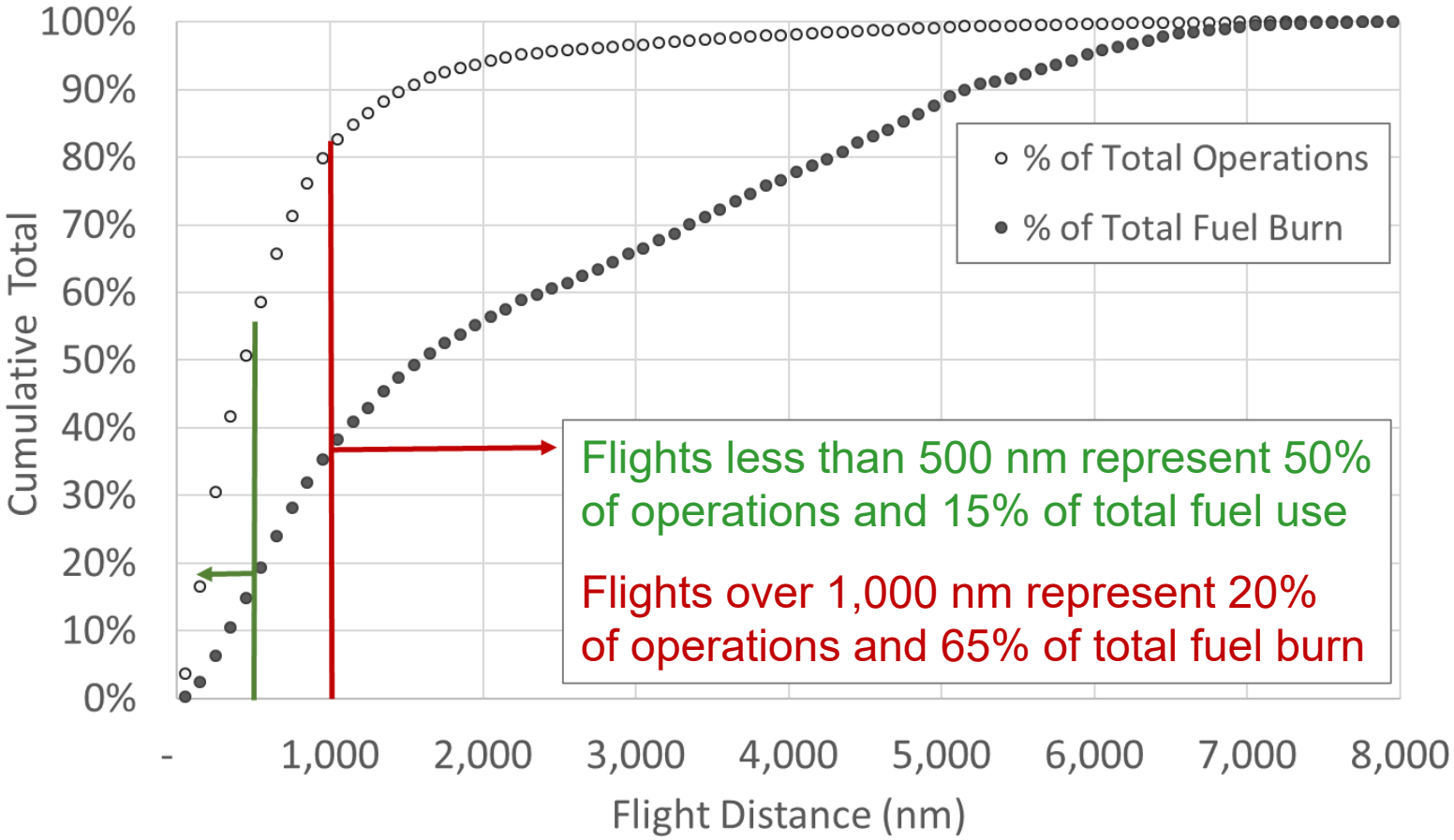




Notes: * Gasoline-Gallon Equivalents (GGE) are used to compare gasoline, diesel, and electricity on a level basis. Alterations to the source data were made to account for the inefficiencies of electricity production. This impacts rail the most because it has the highest level of electric power.
** Domestic flights only. All fuel use is attributed to passengers, none to cargo that might be using the same airplane.
*** Includes passenger cars, vans, and small buses operating in response to calls from passengers to the transit operator who dispatches the vehicle.

Global Jet Fuel Use

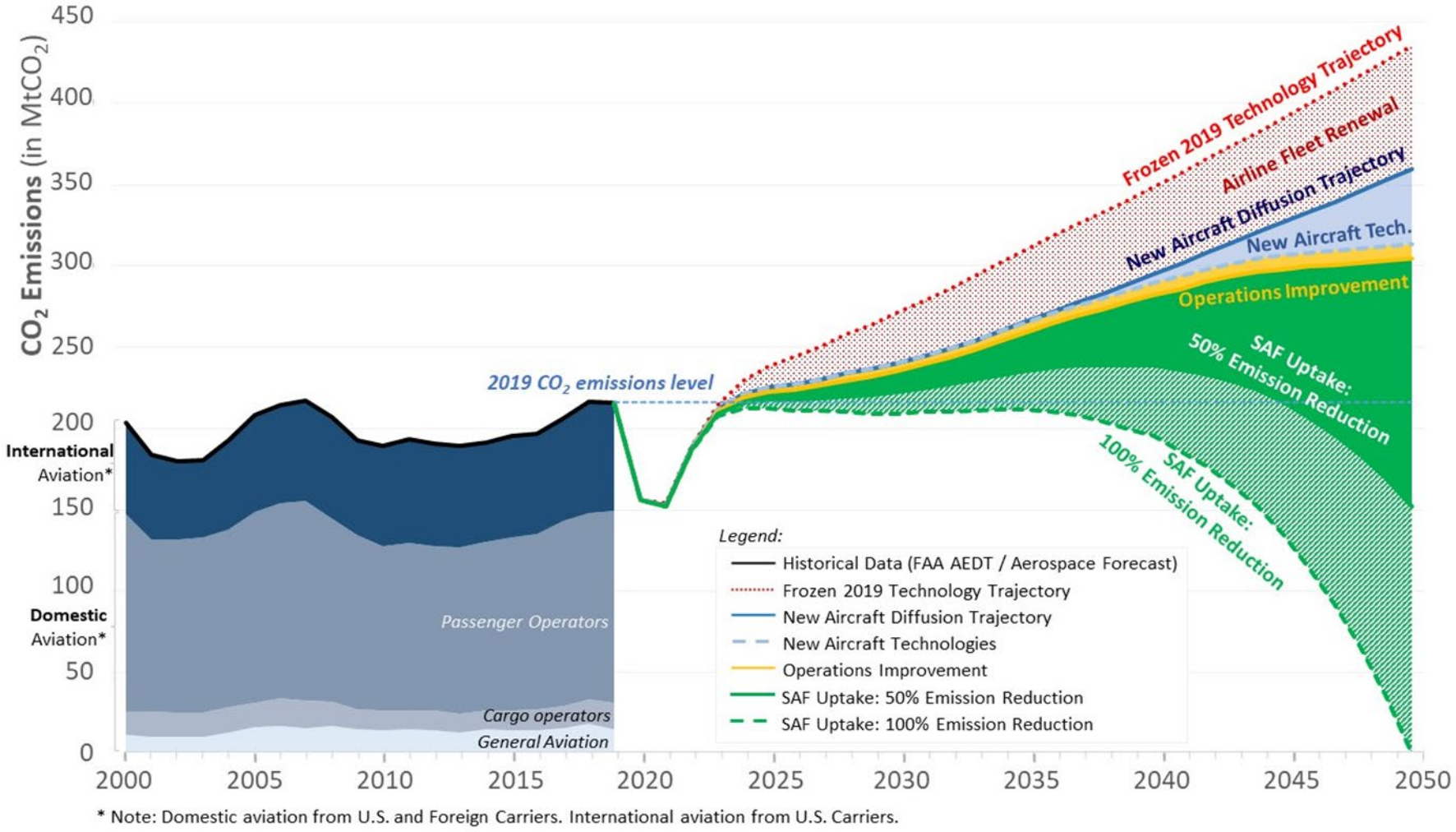
- Global jet fuel use is driven by long-haul aviation
- SAF only option through 2050 for long distances



Data analysis conducted by the U.S. DOT Volpe Center using the Aviation Environmental Design Tool (AEDT)

Federal Aviation Administration

Analysis of Future Domestic and International Aviation CO_2 Emissions



* Note: Domestic aviation from U.S. and Foreign Carriers. International aviation from U.S. Carriers.

NOTE: Analysis conducted by BlueSky leveraging FAA Aerospace Forecast and R&D efforts from the FAA Office of Environment & Energy (AEE) regarding CO2 emissions contributions from aircraft technology, operational improvements, and SAF

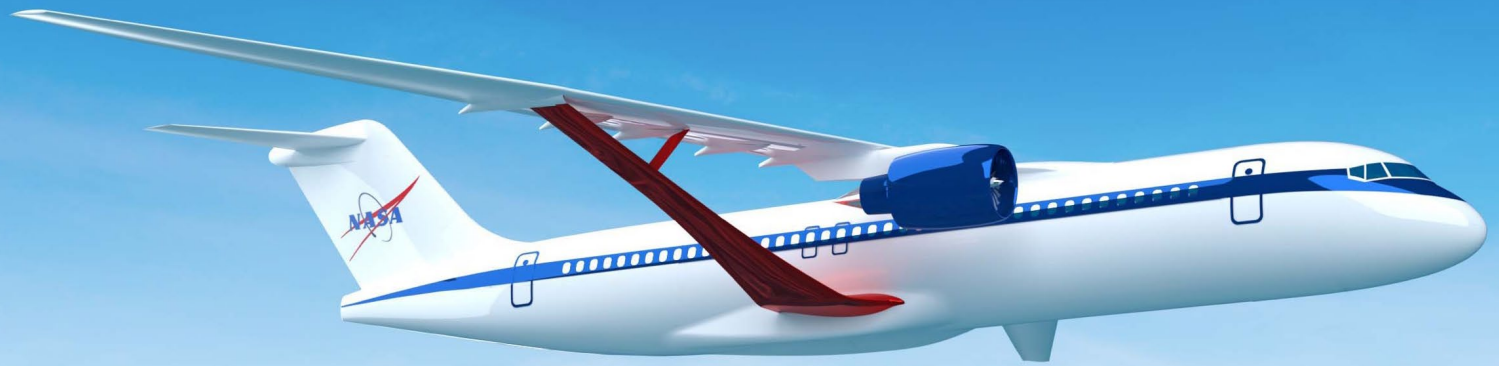
Sustainable Flight National Partnership

A sustained major technology development initiative, under which NASA and the FAA will work with industry, to accelerate the maturation of aircraft and engine technologies that enable a step-change reduction in fuel burn, emissions, and noise, (i.e., 25-30% lower fuel burn and 10-15 decibel noise reduction relative to best-in-class aircraft today).

SFNP will build upon successful cooperation among FAA, NASA, and industry:

- NASA's investments under the SFNP include a suite of integrated, large-scale aircraft and propulsion flight and ground technology demonstrations, including ultra-efficient wings (such as transonic truss-braced wings), small-core gas turbines, electrified and hybrid electric aircraft propulsion system(s), and new manufacturing techniques such as high-rate composite manufacturing to enable rapid production of such new aircraft.
- FAA R&D is focused on engine technologies, low-emissions combustion, and aircraft technologies that enable future operational concepts. At the FAA, these technology development efforts will be executed primarily under the CLEEN Program and the ASCENT Center of Excellence.

SFNP will initially target narrow-body aircraft family as it accounts for 55% of future global market value ($3.7 trillion), 40% of CO_2 emissions from commercial operators globally, and 60% of domestic population exposure to significant noise.



Aircraft Technology

Through the Continuous Lower Energy, Emissions, and Noise (CLEEN) Program, FAA are working in a public-private partnership with industry to accelerate maturation of certifiable aircraft and engine technologies.

- Technological innovation will be essential to enable environmentally sustainable growth and maintain U.S. global leadership.

- FAA have been operating CLEEN Program since 2010 (initially set up during Bush administration)

- FAA announced CLEEN Phase III on Sept 9, 2021

- Summary of CLEEN accomplishments over first two phases (10+ years) available online

CLEEN Phase III Technologies

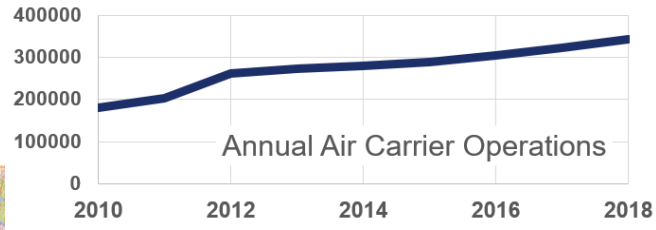
For more information on CLEEN program: http://www.faa.gov/go/cleen

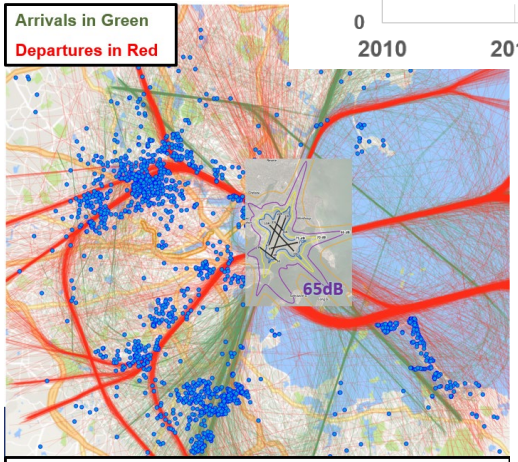
For the CLEEN Phase 3 Press Release:
https://www.faa.gov/newsroom/faa-awards-100m-develop-next-generation-sustainable-aircraft-technology

For a summary of CLEEN Accomplishment:
https://www.faa.gov/newsroom/continuous-lower-energy-emissions-and-noise-cleen-program?newsId=22534

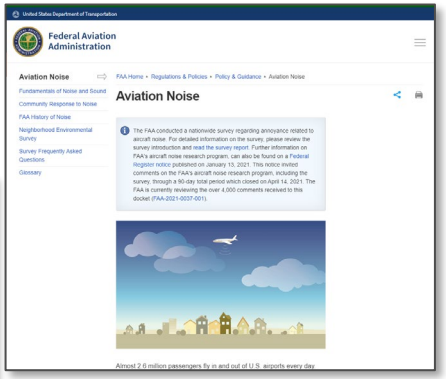
Aircraft Noise

- Recent efforts to modernize the national air transportation system have resulted in concentration of flight paths and other changes
- While air space redesigns have been taking place, operations by air carriers have also increased
- Community concerns about aircraft noise have grown and airport communities that are outside the DNL 65 dB contour are expressing concerns about aircraft noise
- New noise website, Federal Register Notice, and extensive outreach
- Currently conducting a noise policy review

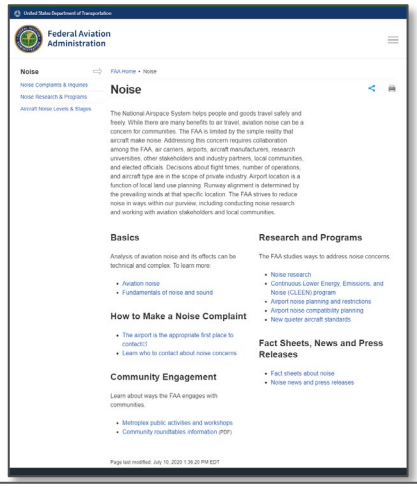




Each marker represents a unique complaint address



www.faa.gov/noise



www.faa.gov/go/aviationnoise

Data Sources: Brenner, M., Hansman, R. J., "Comparison of Methods for Evaluating Impacts of Aviation Noise on Communities," 2017; FAA Data on Annual Air Carrier Operations for Boston Logan International Airport

FRN: https://www.regulations.gov/docket/FAA-2021-0037

Outearch: https://www.youtube.com/watch?v=Mku13gL0xGc

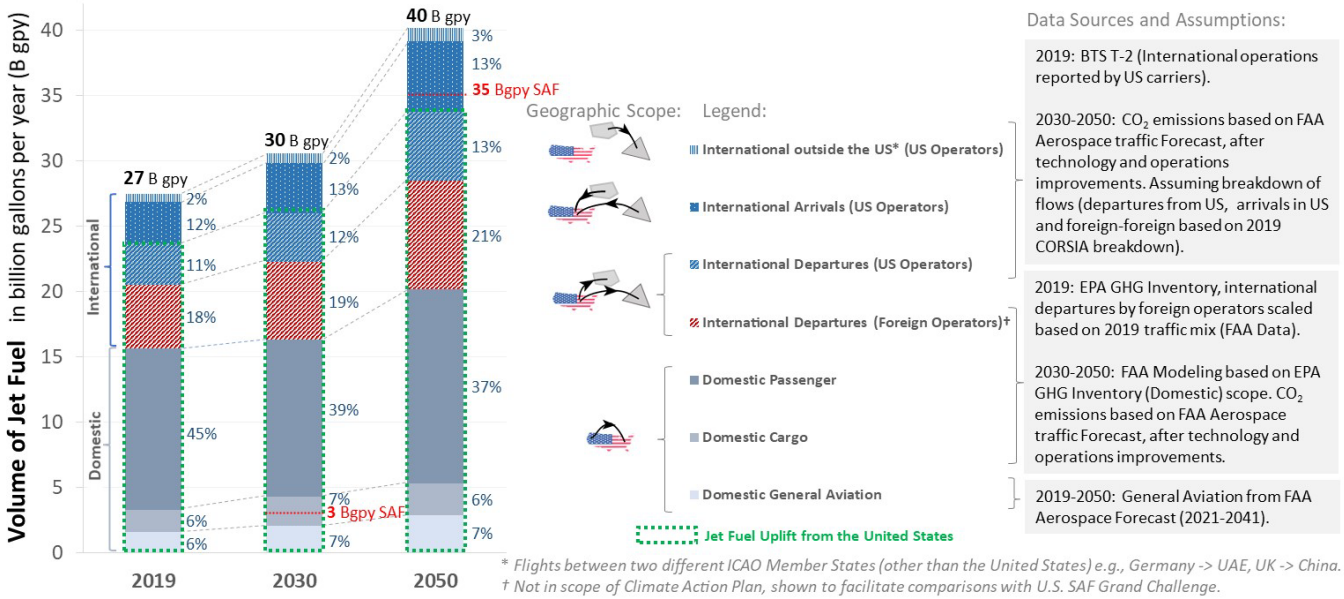
SAF Grand Challenge

https://www.energy.gov/eere/bioenergy/sustainable-aviation-fuel-grand-challenge

The US Government has identified the development and deployment of SAF as a key aviation climate priority. The USG has established a multi-agency effort led by the DOT, DOE, and USDA to implement the "SAF Grand Challenge" to reduce cost, enhance sustainability, and expand production and use of SAF that achieves a minimum of a 50% reduction in life cycle GHGs compared to conventional fuel.

SAF Grand Challenge will include development of a multi-agency roadmap in order to:

- Reduce the cost of SAF
- Enhance sustainability of SAF
- Expand SAF supply and end use



Potential demand for jet fuel in gallons per year (gpy) across domestic operations (by U.S. and Foreign Carriers).

Working to develop SAF Grand Challenge Roadmap – intend to provide extensive details at SAF Summit on June 1 during first day of the CAAFI Biennial General Meeting

Full Report Contents

https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf

- Introduction
- Climate Goals and Approach
- Aircraft and Engine Technology Development
- Operational Improvements
- Sustainable Aviation Fuels
- International Leadership and Initiatives
- Airport Initiatives
- FAA Leadership on Climate, Sustainability and Resilience
- Non-CO_2 Impacts of Aviation on Climate
- Policy and Measures to Close the Gap

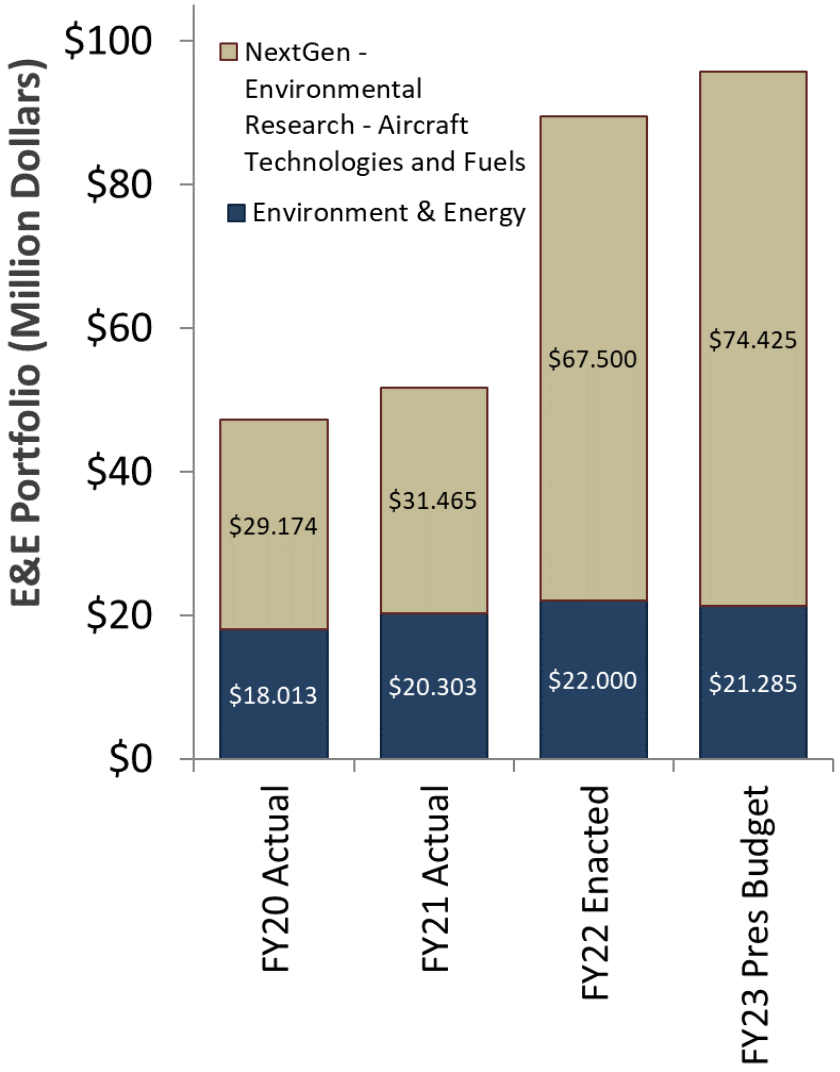
Environmental & Energy R&D Portfolio

RE&D Environment & Energy Budget Line Item*

- Improved understanding of noise and emissions and their impacts
- Analytical tool development
- Analysis to inform decision making

RE&D NextGen – Environmental Research – Aircraft Technology and Fuels Budget Line Item**

- Accelerated development of aircraft and engine technologies with reduced fuel burn, noise and emissions
- Testing, analysis and coordination activities related to Sustainable Aviation Fuels



*Budget Line Items: A12.a (FY20), A.T (FY21), A11.u (FY22), A11.T (FY23)

** Budget Line Items: A12.b (FY20), A.U (FY21), A11.v (FY22), A11.U (FY23)

FY23 President's Budget: https://www.faa.gov/about/budget

CLEEN / ASCENT Budgets

	FY21 Actual	FY22 Enacted	FY23 President's Budget
A11.s Environment and Energy			
CLEEN	$0	$0	$0
ASCENT	$7,500,000	$8,500,000	$7,500,000
Other	$12,803,000	$13,500,000	$13,785,000
Total	$20,303,000	$22,000,000	$21,285,000
A11.t NextGen – Environmental Research – Aircraft Technologies and Fuels			
CLEEN	$19,000,000	$37,500,000	$42,000,000
ASCENT	$9,500,000	$26,565,000	$27,000,000
Other	$3,965,000	$3,435,000	$5,425,000
Total	$32,465,000	$67,500,000	$74,425,000

*Budget Line Items: A.T (FY21), A11.u (FY22), A11.T (FY23)

** Budget Line Items: A.U (FY21), A11.v (FY22), A11.U (FY23)

FY23 President's Budget: https://www.faa.gov/about/budget

FY23 Major Activities

Major Activities	Objective	Expected Outputs	Value Statement	Timeframe
Advance Scientific Understanding of Environmental Impacts of Noise and Emissions	Expand the scientific understanding of the impacts of noise and emissions on people, the environment, and climate.	Knowledge and data on the environmental impacts of noise and emissions.	Provides the understanding of the issues on which technological and operational solutions can be developed	On-going
Aviation Environmental Design Tool (AEDT) Development	Continue expanding the AEDT capabilities of integrated assessment of noise, fuel burn and emissions impacts from commercial aviation by integrating the latest scientific knowledge.	Public release of a new version of the AEDT software.	Provide the analytical capabilities needed for environmental reviews and standards development	On-going effort with annual AEDT releases
Decision Making on Standard Setting, Certification, and Policy	Provide the data and analysis necessary to support the development of appropriate certification procedures, standards, and policies for conventional aircraft, drones, advanced air mobility vehicles and supersonic aircraft.	Analyses and data to support decision making.	Develop the data and information needed to support decision making on both domestic policy and international environmental standards at ICAO CAEP	Second year of a recurring 3-year cycle

FY23 Major Activities (1 of 2)

Major Activities	Objective	Expected Outputs	Value Statement	Timeframe
CLEEN Phase III	Support the maturation of airframe and engine technologies to reduce civil aviation fuel burn, emissions, and noise impacts via one-to-one cost share partnership with manufacturers.	Accelerated maturation of new technologies that could reduce noise, emissions and fuel burn.	CLEEN technologies will produce noise, fuel burn, and emissions benefits throughout the fleet over many years	Year two of the five year CLEEN Phase III Program
ASCENT Technology Innovation	Examine the use of novel technologies and other forms of innovation to reduce noise, emissions, and fuel burn in commercial aircraft.	Improved methods and data to enable the development of technologies and innovative solutions with lower noise, emissions, and fuel burn from subsonic and supersonic commercial aircraft.	The knowledge provided by ASCENT will aid industry in developing solutions to enable quiet, clean, and efficient air transportation.	On-going
Ensure Novel Jet Fuels are Safe for Use	Support the approval of novel jet fuel pathways within the ASTM International certification process through testing and coordination to ensure these fuels are safe for use	Research reports to demonstrate the safety of novel jet fuel pathways for certification by ASTM Intl and streamline the ASTM certification process to reduce the time and cost of certification	The development and approval of new fuel pathways will expand the opportunities to move towards environmental sustainability in a cost-effective manner.	On-going

FY23 Major Activities (2 of 2)

Major Activities	Objective	Expected Outputs	Value Statement	Timeframe
Move Beyond the 50% SAF Blend Wall to Enable 100% SAF Use	Develop and test sustainable aviation fuels through ASCENT, CAAFI, and CLEEN that could be used safely in jet engines without blending with conventional petroleum-based jet fuel	Research reports to demonstrate the safety of sustainable aviation fuel pathways that can be used without blending for certification by ASTM Intl	Eliminate current limitations on environmental benefits of SAF due to current blending constraints	On-going
Maximize environmental benefits of sustainable aviation fuels	Evaluate aviation fuel supply chains within ASCENT to reduce the cost to produce sustainable aviation fuels and maximize their environmental benefits	Analyses and data to support actions by industry and government to cost-effectively produce sustainable aviation fuels with minimal life cycle GHG emissions	Enable aviation industry to cost effectively reach net zero CO_2 emissions through the use of sustainable aviation fuels	On-going
Support inclusion of Sustainable Aviation Fuels in ICAO CORSIA	Support the inclusion of sustainable aviation fuels created from waste and renewable feedstocks, and lower carbon aviation fuels created from fossil feedstocks, within the ICAO CORSIA framework	Develop robust lifecycle greenhouse gas emissions values and methods for alternative fuel pathways and sustainability criteria for use in ICAO CORSIA	High integrity international standards are needed to ensure that sustainable aviation fuels provide CO_2 reductions in a sustainable manner.	On-going

Recent Successes - Capabilities and Solutions Helping Today

Informing Decision Making to Support U.S. Leadership on International Aviation Climate Issues

- Research team provided analysis at the core of the U.S. Aviation Climate Action Plan
- Research team led the development of a comprehensive report on a *long term aspirational goal for international aviation CO_2 emissions* for International Civil Aviation Organization (ICAO).
- Provided critical support to development of *Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA)*.
- Measurement technique and data provided foundation for ICAO CAEP *non-volatile particular matter engine standard* that will replace the existing smoke number standard in 2023.

Supporting the Development of Sustainable Aviation Fuels (SAF)

- *Certification of seven alternative jet fuel pathways and two co-processing pathways* enabling multiple airlines to use SAF in LAX, SFO, and elsewhere. Efforts have also *significantly reduced fuel volumes required for new approvals*.
- Research efforts were critical for the *inclusion of sustainable aviation fuels within CORSIA*.

Accelerating Technological Innovation and the Development of Improved Operational Procedures

- *CLEEN aircraft and engine technologies appearing in new aircraft* with some technologies retrofitted into today's fleet. These technologies and knowledge gained by industry will reduce noise, emissions, and fuel use for decades to come.
- Research efforts are supporting the *introduction of unmanned aircraft systems, advanced air mobility vehicles, and supersonic aircraft* into the air space.
- Developing operational procedure concepts and communication tools at Boston Logan that could *help address noise concerns nationwide*.

Advancing Our Understanding of Noise, Emissions, and their Impacts

- Released *Federal Register Notice on noise research portfolio* with comprehensive community noise annoyance survey quantifying community perceptions on noise. Work is ongoing to understand *impacts of noise on sleep and health*.
- Researchers are advancing our understanding of the impacts of aviation emissions on human health and welfare via *air quality, global climate change, and changes to the ozone layer*.
- Aviation Environmental Design Tool (AEDT) is being used extensively globally to quantify aviation noise and emissions.

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