FAA Office of Environment & Energy Overview and Update

Federal Aviation Administration

Prepared for: CLEEN Consortium Meeting

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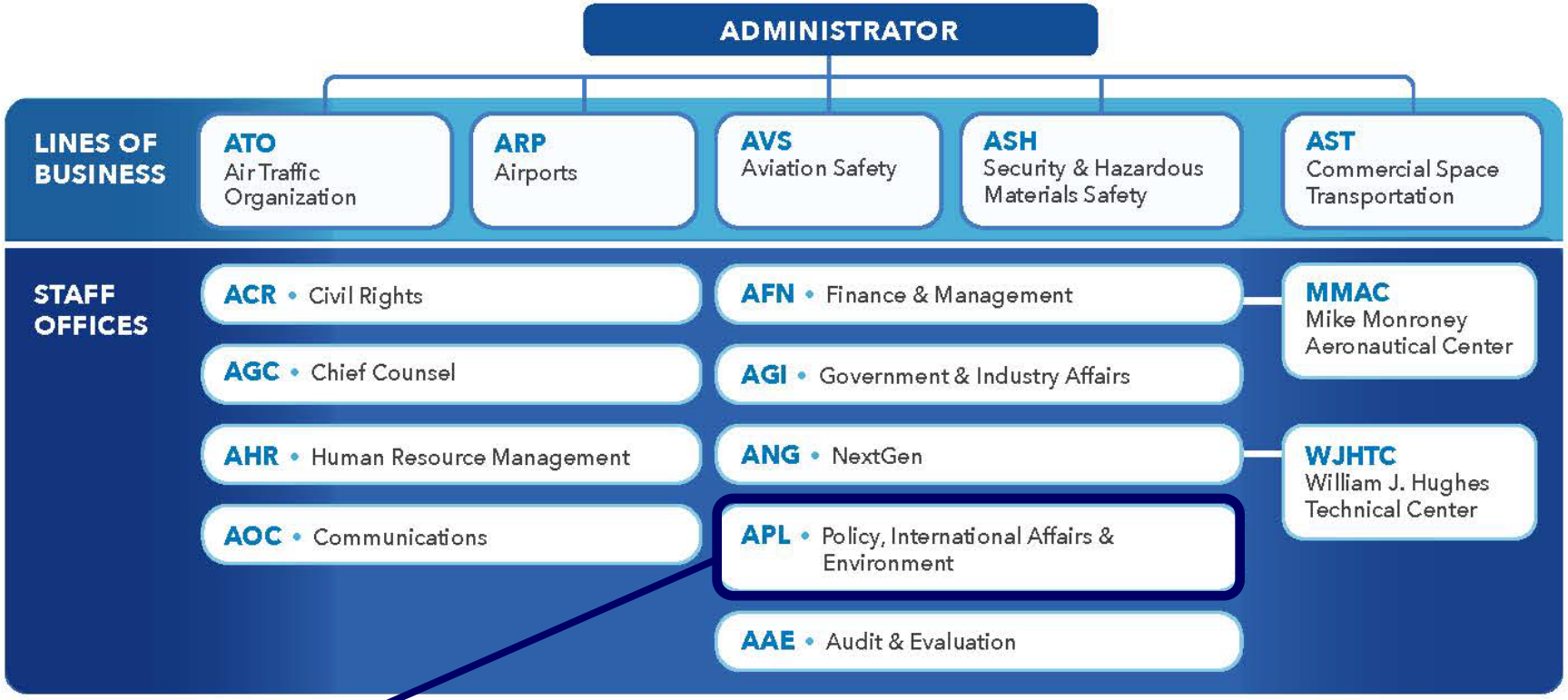
Presentation Outline

- FAA Office of Environment & Energy
- Environment & Energy Strategy
- Aircraft Technology Research & Development
- Sustainable Aviation Fuel Efforts
- Funding Update
- E&E Highlights

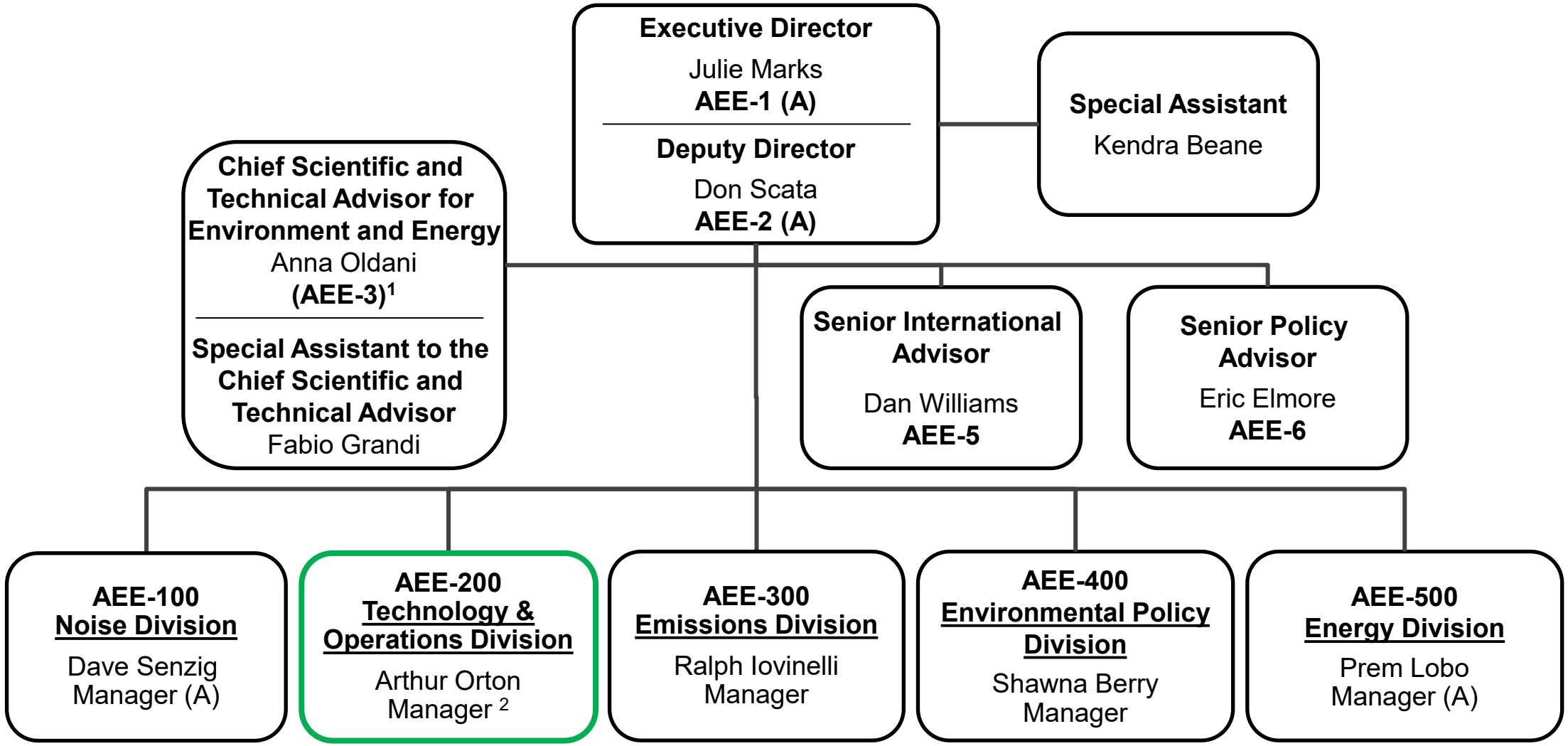
FAA Organizational Structure



Office of Environment and Energy (AEE)

- Office within APL, responsible for broad range of environmental policies
- Roughly 45 staff members
- Responsible for roughly 1/3 of FAA RE&D Budget
- Responsible for the FAA I.R.A. Grant Program

AEE Organizational Structure

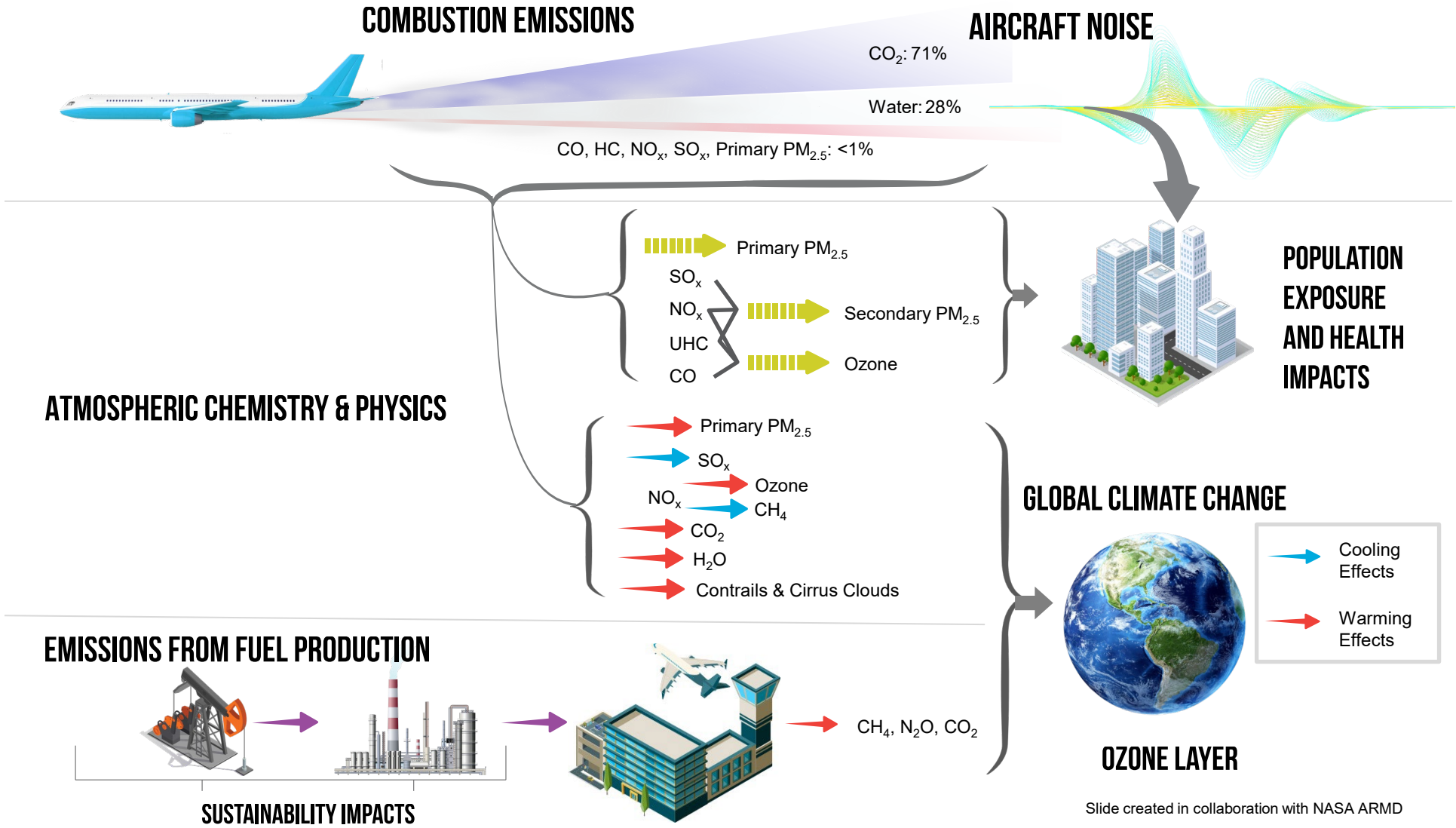


(A) = Acting

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

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

Environmental Impacts of Aviation



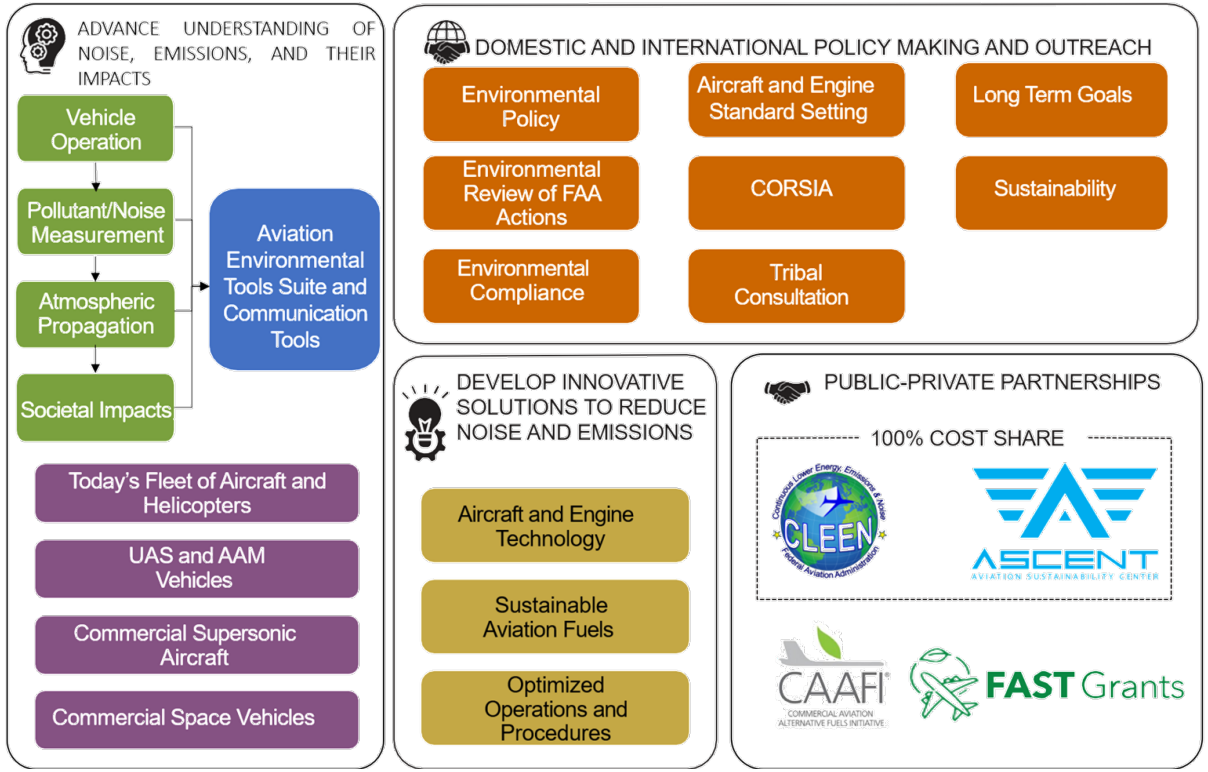
Slide created in collaboration with NASA ARMD

FAA 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/

CAAFI®
www.caafi.org/

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

the VOLPE center

Sustainable Flight National Partnership

A sustained major technology development initiative, under which NASA and 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 dB noise reduction relative to best-in-class aircraft).

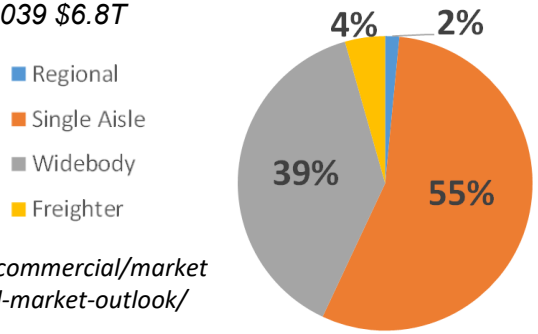
SFNP will build upon successful cooperation among FAA, NASA, and industry:

- 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.

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.

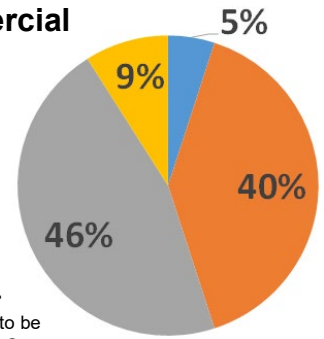
Global Market Value*

2020-2039 $6.8T



**boeing.com/commercial/market/commercial-market-outlook/*

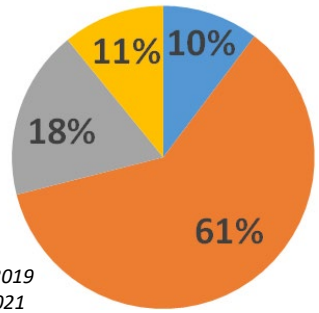
Estimated CO_2 Emissions from Global Commercial Operators** *(2018)*



****Volpe Preliminary Data – used with permission** final data to be published in Chapter 1 of 2022 ICAO Environmental Report

Population Exposed to Significant Noise ***

65 DNL, U.S. CY 2019



**** F. Grandi, AEDT3c, CY 2019 U.S. inventory, 18 March 2021*

Continuous Lower Energy, Emissions & Noise (CLEEN) Program

- FAA led public-private partnership with 1:1 cost matching from industry
- Reducing fuel burn, emissions and noise via aircraft and engine technologies and alternative jet fuels
- Conducting ground and/or flight test demonstrations to accelerate maturation of certifiable aircraft and engine technologies

	Phase I	Phase II	Phase III
Time Frame	2010-2015	2016-2020	2021-2026
FAA Budget	~$125M	~$100M	~$125M
Noise Reduction Goal	25 dB cumulative noise reduction cumulative to Stage 5 and/or reduces community noise exposure (new goal for Phase III)		
Fuel Burn Goal	33% reduction	40% reduction	-20% re: CAEP/10 Std.
NO_X Emissions Reduction Goal	60% landing/take-off NO_X emissions (re: CAEP/6)	75% landing/take-off NO_X emissions (-70% re: CAEP/8)	
Particulate Matter Reduction Goal	-	-	Reduction relative to CAEP/11 Std.
Entry into Service	2018	2026	~2031

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

CLEEN Phase III Technologies

Engine Core
- GE: Compact Core – Low Emissions Combustor
- GE: Advanced Thermal Management
- GE: Hybrid Electric Integrated Generation
- Honeywell: Efficient Green High Pressure Core
- Honeywell: Compact High Work High Lift Low Pressure Turbine (LPT)
- Pratt & Whitney: TALON X+ Combustor
- Rolls-Royce Axi-Cf Compressor Technologies

Airframe
- Boeing: Quiet Landing Gear
- Boeing: Quiet High-Lift System

Aircraft Systems
- GE: MESTANG III
- Boeing: Intelligent Operations

Sustainable Aviation Fuels
- Boeing: Higher Blend SAF Qualification
- GE: Higher Blend SAF Qualification

Nacelle, Fan, and Bypass
- America's Phenix: Erosion-Resistant Fan Blade Coating
- Boeing: Advanced Nacelle Next Generation Inlet
- Collins: Large Cell Exhaust Acoustic Technology
- Collins: Titanium Inner Fixed Structure
- GE: Open Fan
- GE: Advanced Acoustics
- Honeywell: Highly Efficient Fan Module
- Pratt & Whitney: Ultra-Quiet Reduced-Loss Fan Stage
- Safran: Acoustic Air Inlet Lip Skin

Fuel
Emissions
Noise

Assessment of CLEEN Technologies

Analytical Evaluation:

- Conducted by Georgia Tech through ASCENT COE Project 37
- Evaluating impact of technology applications through 2050
- Have completed modeling and assessment of CLEEN Phase I and II technologies and their fuel burn and NOx impacts

Fuel Burn Benefit:

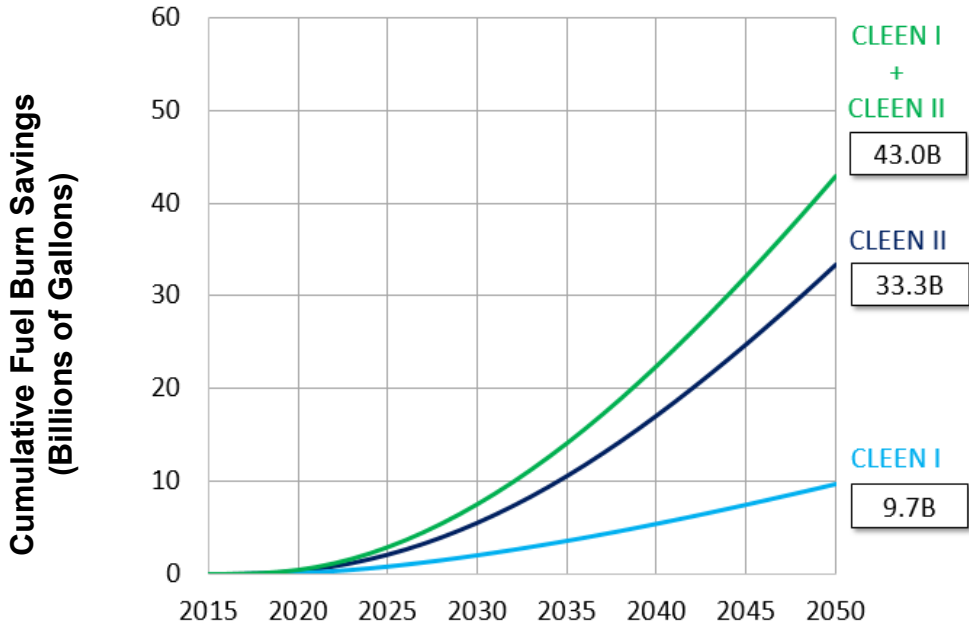
- 43.0 billion gallons of fuel saved cumulative by 2050 from CLEEN Phase I and II
- CO_2 emissions reduced by more than 400 million metric tons over this time period

NOx Benefit:

- CLEEN Phase I and II technology cumulatively reduce LTO NOx emissions by 2.79 Megatons through 2050

Noise Benefit:

- Updated noise benefits assessment including all CLEEN I and II technologies expected to be complete this Fall



Updated 11/2023

Continuous Lower Energy, Emissions & Noise (CLEEN) Program

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- Reducing fuel burn, emissions and noise via aircraft and engine technologies and alternative jet fuels
- Conducting ground and/or flight test demonstrations to accelerate maturation of certifiable aircraft and engine technologies

	Phase I	Phase II	Phase III	Phase IV (DRAFT)
Time Frame	2010-2015	2016-2020	2021-2026	2025-2029
FAA Budget	~$125M	~$100M	~$125M	~$190M
Energy Efficiency / Fuel Burn Reduction Goal	33% reduction re: year 2000 baseline	40% reduction re: year 2000 baseline	-20% re: CAEP/10 Std.	-35% re: CAEP/10 Std., and/or reduces aviation's climate impacts
Noise Reduction Goal	25 dB cumulative noise reduction cumulative to Stage 5 and/or reduces community noise exposure (new goal for Phase III)			
NO_X Emissions Reduction Goal	60% landing/take-off NO_X emissions re: CAEP/6	-70% landing/take-off NO_X emissions re: CAEP/8 (-75% re: CAEP/6)		-70% landing/take-off NO_X emissions re: CAEP/8 and/or reduces absolute NOx over the aircraft's mission
Particulate Matter Reduction Goal	-	-	Reduction relative to CAEP/11 Std.	-50% landing/take-off nvPM number and mass re: CAEP/11
Entry into Service	2018	2026	~2031	~2035

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

ASCENT Technology Projects

- **Complementary venue for university-led research on aircraft technology research and development**
- **Advances the industry state-of-the-art and expands the technical knowledge base**
- **Cuts across development of individual technologies and models**
- **Technical Themes:**
  - Noise reduction technology modeling and development
  - System-level modeling and design considerations
  - Propulsion-airframe integration
  - Combustion
  - Turbomachinery
  - Supersonics
- **Overview of projects available on ASCENT website:**

  https://ascent.aero/topic/Aircraft-Technology/

ASCENT Aircraft Technology Innovation Portfolio

Noise reduction technology modeling and development

- 075 - Improved Engine Fan Broadband Noise Prediction Capabilities
- 076 - Improved Open Rotor Noise Prediction Capabilities
- 079 - Novel Noise Liner Development Enabled by Advanced Manufacturing

System-level modeling and design considerations

- 010 - Aircraft Technology Modeling and Assessment
- 037 - CLEEN II System Level Assessment
- 052 - Comparative Assessment of Electrification Strategies for Aviation
- 064 - Alternative Design Configurations to Meet Future Demand
- 095 – Assessment of Fuel Cells for Powering Modern Business Jets
- 096 – Future Transportation System Opportunities and Constraints
- 097 – FAST-Tech System Level Assessment

Propulsion-airframe integration

- 050 - Over-Wing Engine Placement Evaluation
- 063 - Parametric Noise Modeling For Boundary Layer Ingesting Propulsors

Supersonics

- 047 - Clean Sheet Supersonic Aircraft Engine Design and Performance
- 059 - Jet Noise Modeling to Support Low Noise Supersonic Aircraft Technology Development

Combustion

- 051 - Combustion concepts for next-generation aircraft engines to reduce fuel burn and emissions
- 055 - Noise Generation and Propagation from Advanced Combustors
- 066 - Evaluation of High Thermal Stability Fuels
- 067 - Impact of Fuel Heating on Combustion and Emissions
- 068 - Combustor Wall Cooling Concepts for Dirt Mitigation
- 070 - Reduction of nvPM emissions via innovation in aero-engine fuel injector design
- 071 - Predictive Simulation of Soot Emission in Aircraft combustors
- 074 - Low Emissions Pre-Mixed Combustion Technology for Supersonic Civil Transport
- 098 – Low Emissions Lean Pre-Mixed Pre-Vaporized Combustion Technology for Subsonic Civil Transport

Turbomachinery

- 056 - Turbine Cooling Through Additive Manufacturing
- 092 – Advanced Two-Stage Turbine Rig Development

Green = new projects pending award

FAST Program Overview

The new **Fueling Aviation's Sustainable Transition (FAST)** discretionary grant program will make investments to accelerate production and use of **sustainable aviation fuels** and the development of **low-emission aviation technologies** to support the U.S. aviation climate goal to achieve net zero greenhouse gas emissions by 2050.

Grants will carry out projects located in the United States that:

- Produce, transport, blend or store sustainable aviation fuel (**FAST-SAF**) - $244,530,000
- Develop, demonstrate, and apply low-emission aviation technologies (**FAST-Tech**) - $46,530,000

Notice of Funding Opportunity released September 25, 2023:
https://www.grants.gov/web/grants/view-opportunity.html?oppId=350315

Range of Potential Projects - Details

Two project categories being considered for the FAST-Tech Program:

1. Designing, prototyping, and testing of discrete low-emission aviation technologies
   - Relatively near-term impact on emissions from future engine and aircraft designs
   - Technologies might be limited vehicle types or specific company product lines
   - Similar to technology development efforts in CLEEN and ASCENT
2. Enhancing aircraft and engine technology testing and demonstration capabilities to accelerate development and demonstration of a broad range of low-emissions aviation technologies.
   - Longer-term impact on emissions from future engine and aircraft designs
   - Support development of tech over broad range of vehicle types
   - Impact of projects could endure for long time period and help entire industry
   - Improve understanding of technologies to enable future benefits
   - AEE currently standing up one project within ASCENT that fits in this category (ASCENT Project 92 at Penn State University to expand turbine facility)

Summarizing FAA Environmental Aircraft Technology Programs

- **CLEEN**
  - Industry partnership with 50/50 cost share via cooperative agreements
  - Focused on taking TRL 3-5 technologies through TRL 6-7 to reduce technical risk and put technologies on a path for entry into service ~5 years after conclusion of R&D
  - Focused technology development with additional benefits to enhancing analysis and design tools
- **Aviation Sustainability Center of Excellence (ASCENT)**
  - Academic partnership with 50/50 cost share via grants
  - Focused on applied R&D at any TRL
  - Advances state of the art of knowledge broadly in the industry
  - Covers: new discrete technologies, enhanced analysis and design tools, and improved physics modeling
- **Fueling Aviation's Sustainable Transition via Technology (FAST-Tech)**
  - Industry and/or academia partnership with 75% FAA cost share via grants
  - Explicitly focused on low-emissions technologies
  - *Focus areas:*
    - *Designing, prototyping, and testing of discrete low-emission aviation technologies, and*
    - *Enhancing aircraft and engine technology testing and demonstration capabilities to accelerate development and demonstration of a broad range of low-emission aircraft technologies.*

SAF Grand Challenge

Multi-agency roadmap for the next decade of work to enable SAF Grand Challenge Goals

Achieve 3 billion gallons of domestic SAF production in 2030 and put U.S. on trajectory to 35 billion gallons per year by 2050

At least a 50% reduction in life cycle greenhouse gas emissions, as compared to conventional jet fuel

Roadmap Addresses Six Key Action Areas

1. Feedstock Innovation
2. Conversion Technology Innovation
3. Building Supply Chains
4. Policy and Valuation Analysis
5. Enabling End Use
6. Communicating Progress and Building Support

Roadmap contains 2022-2030 & 2030-2050 timeframes

https://www.energy.gov/eere/bioenergy/articles/sustainable-aviation-fuel-grand-challenge-roadmap-flight-plan-sustainable

Building the Foundation – Consistent and Dedicated Resources Towards Scaling Up Sustainable Aviation Fuels

Testing
accelerate SAF development

- Test fuels
- Improve testing methods
- Conduct evaluation
- Streamline approval

Analysis
environmental and economic sustainability

- Lifecycle emissions
- Cost reduction
- Supply potential
- Supply chain opportunities

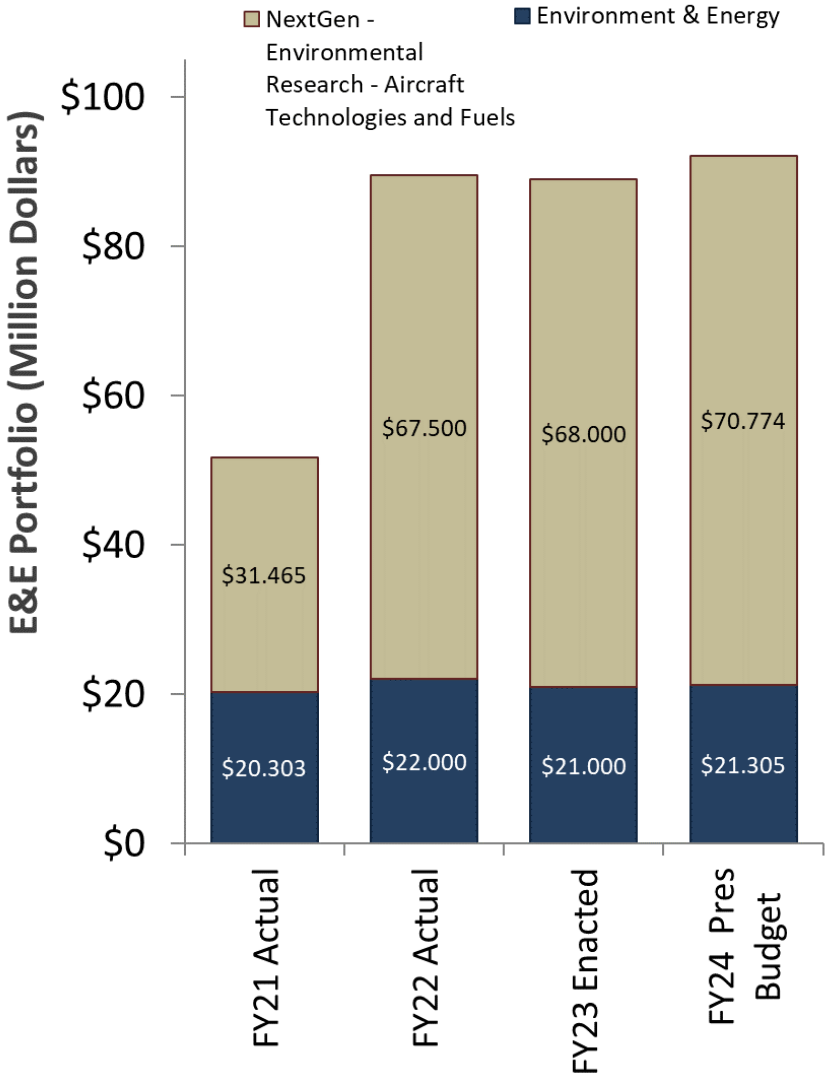
Coordination
support SAF integration

- Public-private partnership – *CAAFI*
- U.S. interagency cooperation
- International cooperation – *ICAO*

Deployment
enable SAF scale-up

- Build production, transportation, blending and storage infrastructure – *FAST*

E&E R&D Portfolio

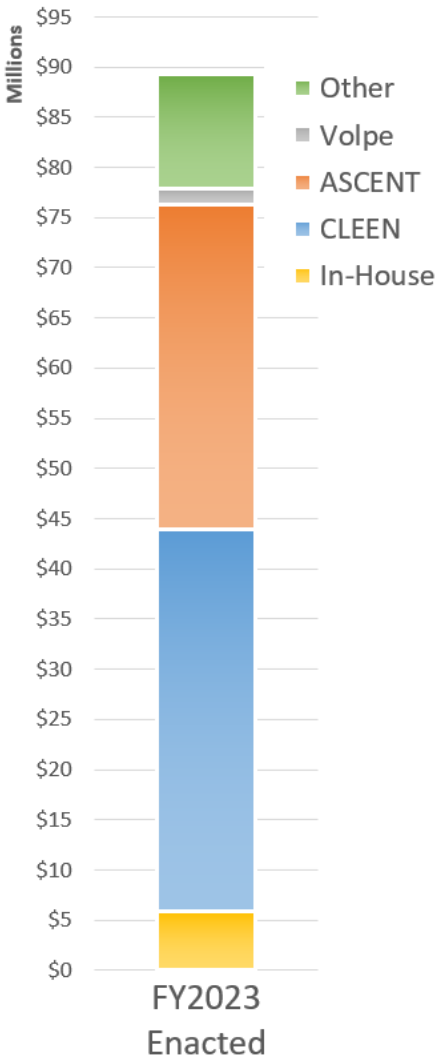


RE&D Environment & Energy (E&E) Budget Line Item

- 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
- FY23 CLEEN Earmarks - $38M



Highlights of Ongoing R&D Efforts (E&E R&D Portfolio)

- Progressing ICAO dual stringency standards for CO2 Emissions and Noise
- NOFO for the IRA funded FAST-SAF and FAST-Tech Grant Programs expected for the Fall
- Published Noise Policy Review request for comments via Federal Register (closes Sept 29)
- Noise certification via Rules of Particular Applicability for six sUAS
- UAS package delivery environmental assessment in major US metro area (EA not public yet)
- Modernization of Special Airworthiness Certification (MOSAIC) noise certification of non-TC'ed aircraft
- Completed year 2 of CLEEN Phase III aircraft technology research efforts
- Initiated CLEEN Phase IV planning for 2024 solicitation
- Advancing 2 final rulemakings: Airplane Fuel Efficiency and Engine nvPM emissions standards
- Expanded collaboration/partnerships regarding condensation trails research with NASA, DOE, German DLR, Industry
- Advancing fuel qualification – 3 additional routes added
- SAF Grand Challenge implementation - technical support to SAF tax credits
- Outreach – 8 CAAFI webinars; 1 CAAFI virtual conference; and, 1 North American SAF conference
- Global SAF capacity building – ASCENT project 93 progress: 13 countries; 3 regions; 3 workshops; 2 PhD students; 1 training program

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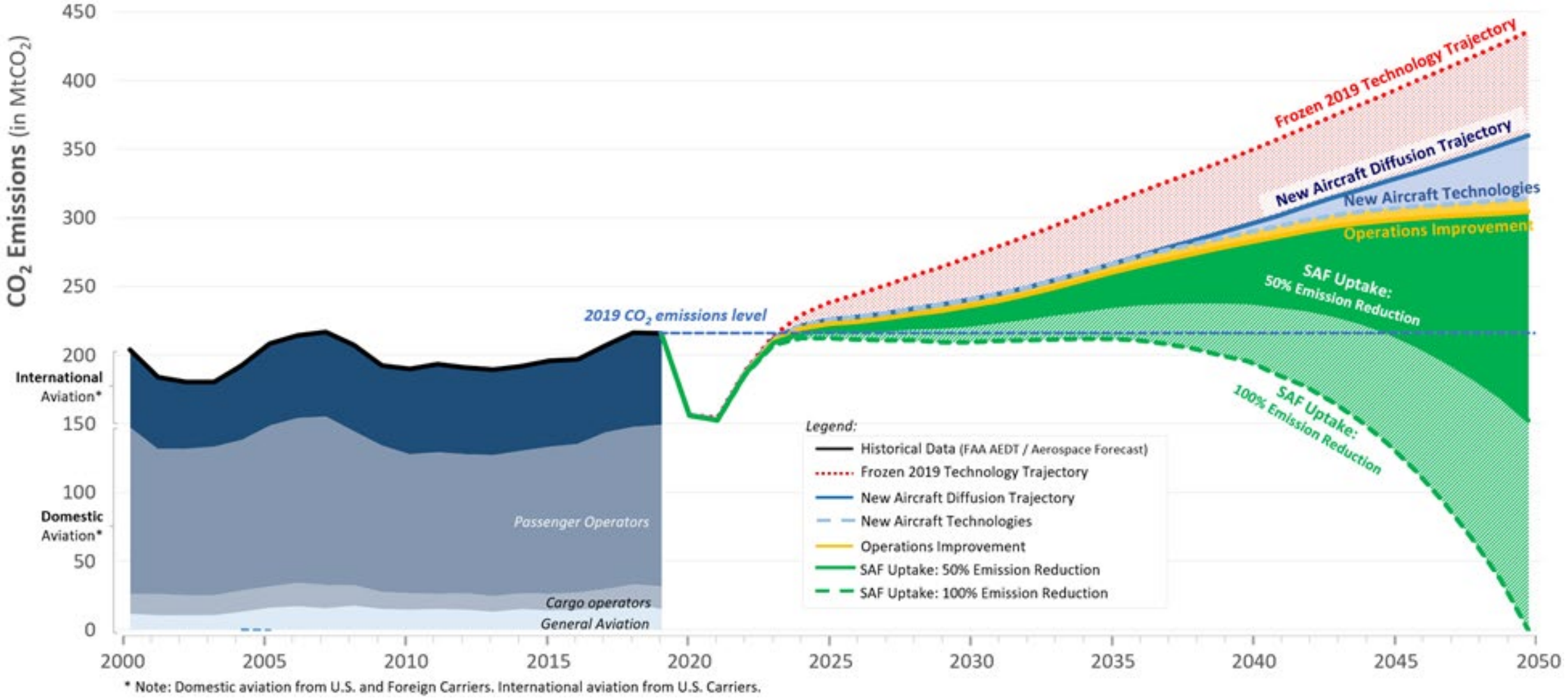
Backup

Domestic and International Aviation CO_2 Emissions



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