Policymaking in the U.S. to Support Innovative Aviation Technologies

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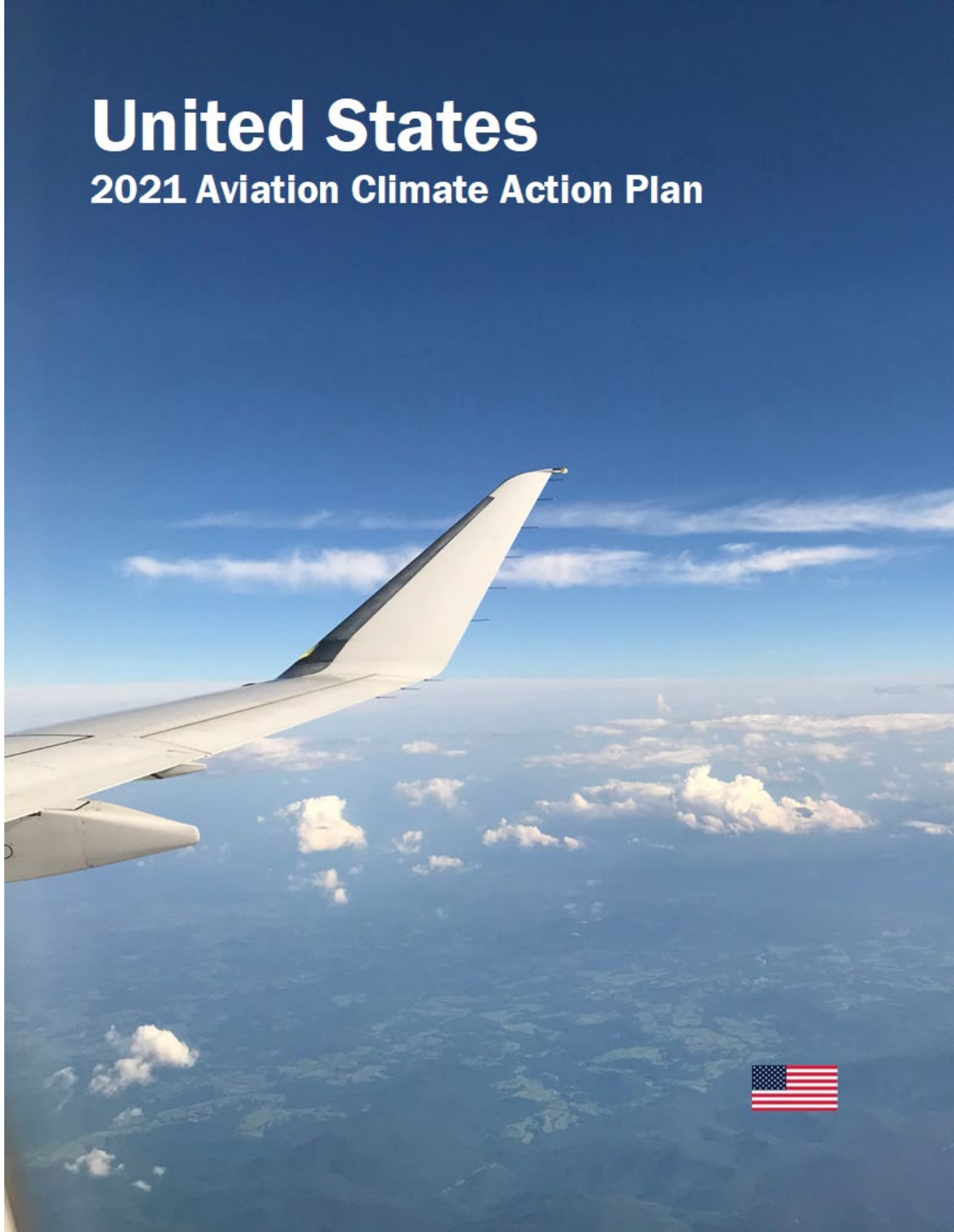
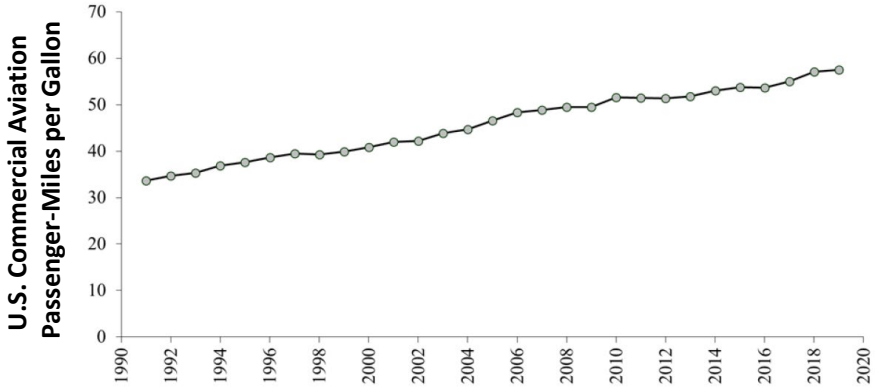
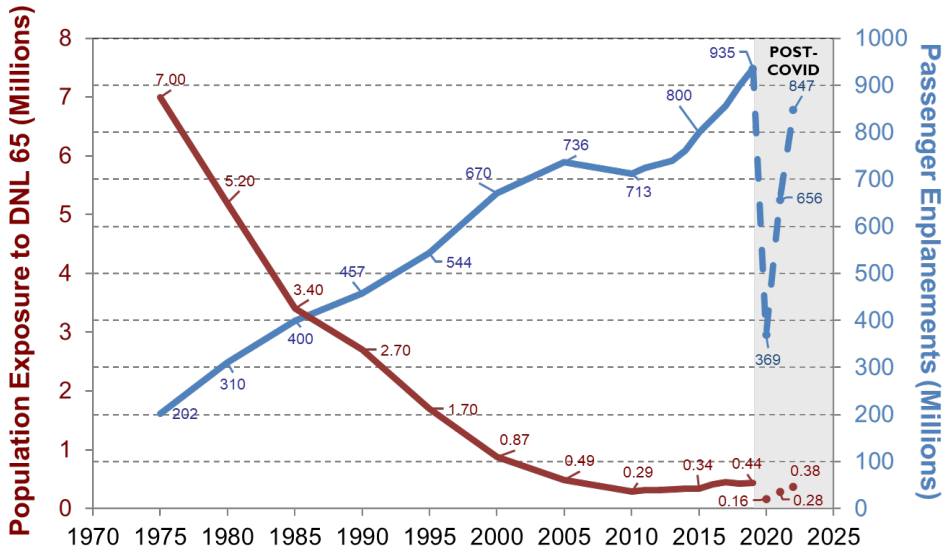


Rationale for Investing in Aircraft Technology

- Historically, advances in aircraft technology have been the main factor in reducing aviation's environmental impact
- Continued improvements come with large technological risk
- Small profit margins, competitive/cost pressures, and supply chain disruptions have considerably reduced industry's ability to undertake research to advance new technologies to reduce noise and emissions
  - **However**, industry has also set ambitious net zero targets
- SAF scale-up has challenges and cannot be the only solution
  - Technology improvements can make SAF go farther
- Government resources help mitigate technological risk and incentivize aviation manufacturers to invest in and develop cleaner, quieter technology





Sustainable Flight National Partnership

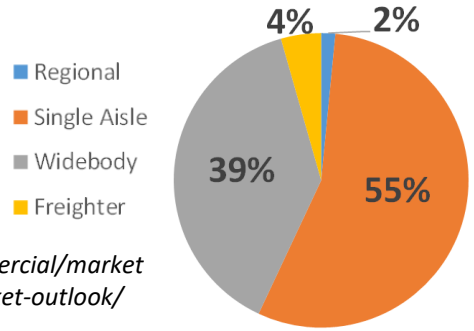
A sustained major technology development initiative, under which NASA and FAA will work with industry, to accelerate the maturation of aircraft and engine technologies that enable a step-change reduction in fuel burn, emissions, and noise (i.e., 25-30% lower fuel burn and 10-15 dB noise reduction relative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

- **NASA Investments:**
  - Suite of integrated, large-scale aircraft and propulsion flight and ground technology demonstrations: ultra-efficient wings (such as transonic truss-braced wings), small-core gas turbines, electrified and hybrid electric aircraft propulsion system(s)
  - New manufacturing techniques: high-rate composite manufacturing to enable rapid production of new aircraft
- **FAA R&D:**
  - Engine technologies, low-emissions combustion, airframe noise reduction, and aircraft technologies that enable future operational concepts
  - Technology development efforts will be executed primarily under the CLEEN Program, ASCENT and FAST-Tech

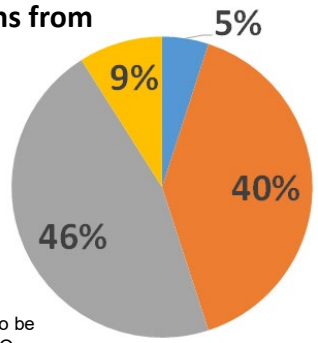
Initially target narrow-body aircraft family as it accounts for 55% of future global market value ($3.7 trillion), 40% of CO_2 emissions from commercial operators globally, and 60% of domestic population exposure to significant noise.

Global Market Value*

2020-2039 $6.8T

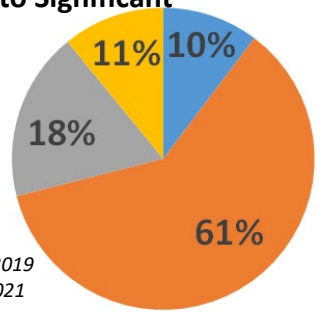


Estimated CO_2 Emissions from Global Commercial Operators* *(2018)*



Population Exposed to Significant Noise ***

65 DNL, U.S. CY 2019



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

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

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

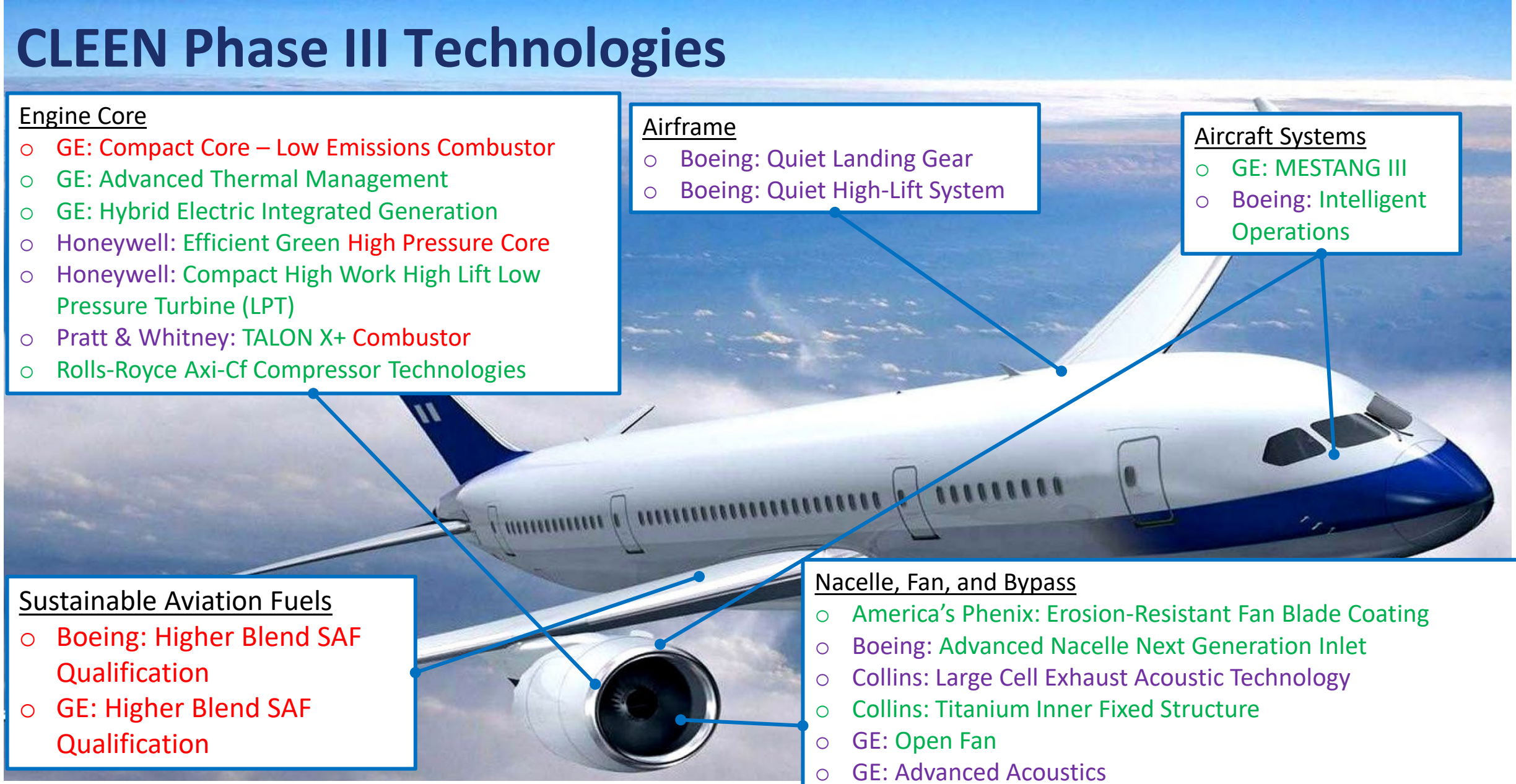
Continuous Lower Energy, Emissions & Noise (CLEEN) Program

- 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 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:

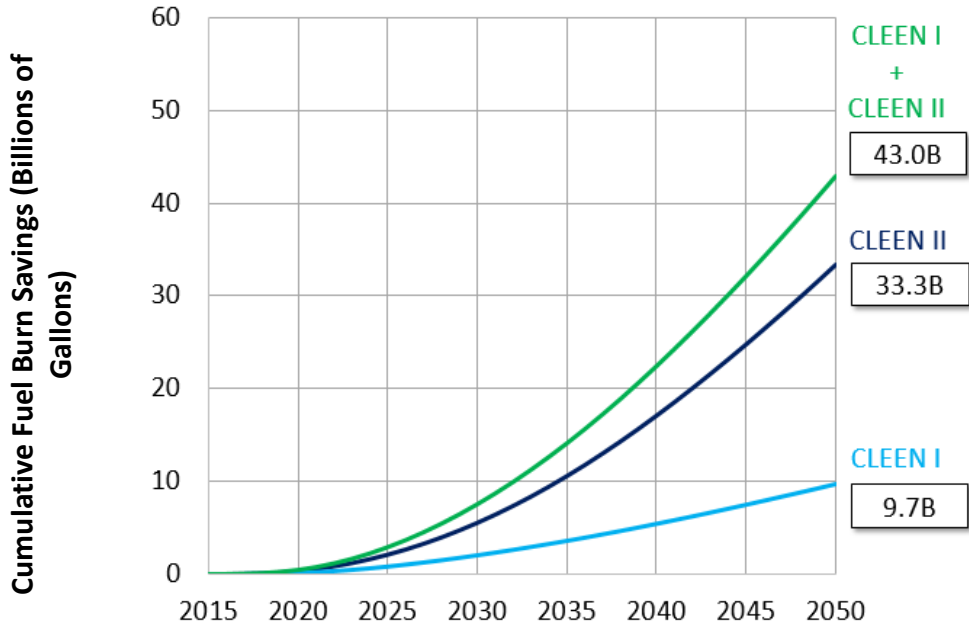
- **43.0 billion gallons of fuel saved** cumulative by 2050 from CLEEN Phase I and II
- **CO_2 emissions reduced by over 400 million metric tons** over this time period

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 11/30/2023