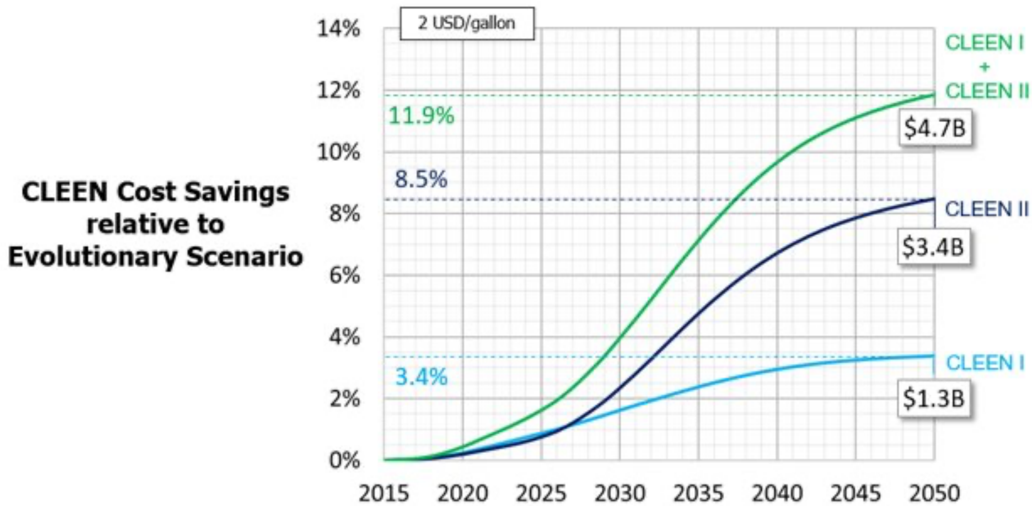


Note: Not all technologies are modeled/included at this time.

Note: CLEEN II contributions are shown as an annual (not cumulative) benefit.

Note: Results assume a constant fuel cost of 2 USD/gallon.

Figure 1. Preliminary fuel burn assessment: savings relative to the CLEEN evolutionary scenario (updated).

According to the analysis presented above, the technologies that have matured in the first 5-year phase of CLEEN will reduce U.S. fleet-wide fuel burn by 1.6% by the year 2030 and 3.4% by 2050 relative to the evolutionary scenario, thus providing a cumulative savings of 11.6 billion gallons of jet fuel. The CO_2 savings are the equivalent of taking 977,000 cars off the road in the years 2020–2050.

This preliminary analysis projects that the technologies matured in the CLEEN II program will reduce fuel consumption by 2.4% by 2030 and 8.5% by 2050 relative to the evolutionary scenario, thus bringing the contribution of CLEEN I and II to a fuel burn reduction of 11.9% in the fleet by 2050.

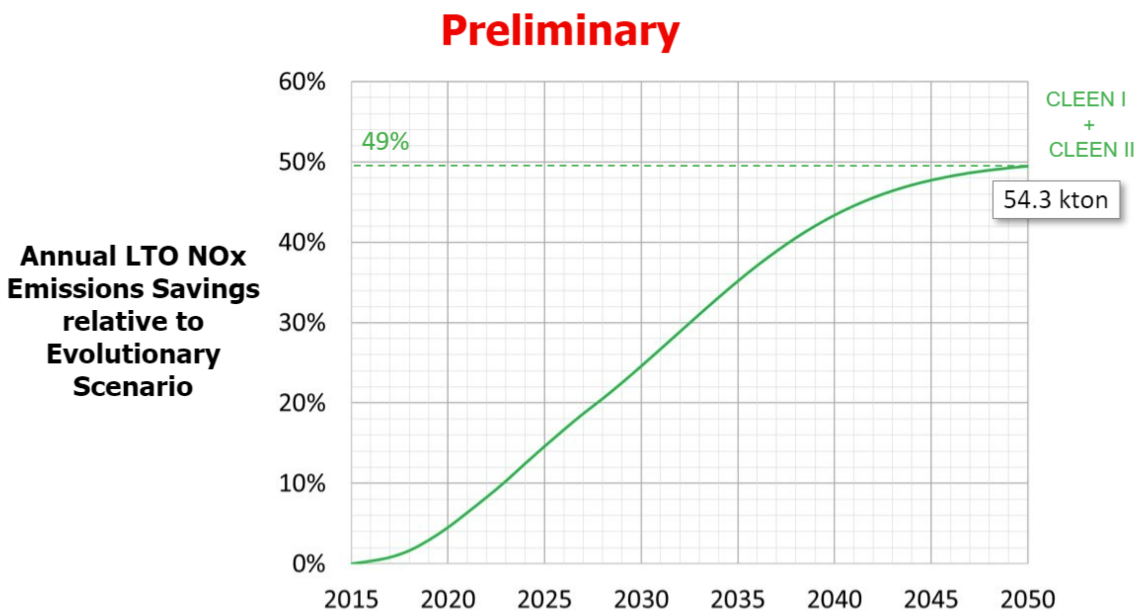
Cumulatively, the CLEEN I and II programs are estimated to save 36.1 billion gallons of fuel by 2050, resulting in a savings of approximately 72.2 billion dollars for airlines and a reduction in CO_2 emissions of approximately 420 million metric tons. These CO_2 reductions are equivalent to removing 3.03 million cars from the road in the years 2020–2050.

Preliminary LTO NOx Assessment

GT presented a preliminary LTO NOx emission assessment in Spring 2022. This fleet assessment is identical to the fleet fuel burn assessment of the considered fleet replacement matrices, demand forecast, technology integration scenarios, and scope of domestic flights with international departures. Among the existing collection of fuel burn technologies, the following CLEEN combustor technologies are represented:

- GE TAPS II (GT model)
- GE TAPS III
- Rolls-Royce RQL combustor
- Honeywell compact combustor

In-house modeling was performed at GT for which cases in which contractor models were unavailable and for the integration, baseline, and vehicles of each relevant fixed technology. The GT modeling approach, a P3T3 method, relied on correlations linking the emission index for NOx production of an individual combustor to the conditions of the core flow entering the combustor (DuBois, D., & Paynter, G. C., 2006). The boundary conditions defining this relation for each of the four LTO cycle points, i.e., take-off, climb-out, approach, and idle, are defined by the aircraft emission databank of the International Civil Aviation Organization and GT in-house engine models (ICAO, n.d.).



Note: Not all technologies are modeled/included at this time.

Note: CLEEN II contributions are shown as an annual (not cumulative) benefit.

Figure 2. Preliminary lift/take-off (LTO) NOx fleet emission assessment: reduction relative to the CLEEN evolutionary scenario.

According to the fleet emission analysis performed above, the technologies matured in the CLEEN program will reduce U.S. fleet-wide NOx emissions in the LTO cycle by 24.6% by the year 2030 and 49.4% by 2050 relative to the evolutionary scenario, thus providing a cumulative reduction of 997 kton LTO NOx.

The fleet-level noise benefit assessment of CLEEN II is underway. Results are expected to be complete in early 2023.

Milestones
Completion of CLEEN II fleet noise, fuel burn, and NOx emissions assessment.

Major Accomplishments
N/A

Publications
None.

Outreach Efforts
- CLEEN consortium presentation and panel participation.

Awards
None.

Student Involvement
Six graduate students are currently receiving funding from this effort.

Plans for Next Period

Future work will focus on completing technology modeling and updating fleet analysis assessments for the remaining technologies. The next period will also include the transition of efforts toward the incoming CLEEN III initiative.

This transition will include an update to the current fleet assessment assumptions regarding the exercised demand forecast, replacement matrix, technology integration scenarios, and baseline vehicles.

This work will also support attendance at CLEEN consortium meetings and contractor preliminary and detailed design reviews to identify any updates required for the technology models developed in prior years.

References

DuBois, D., & Paynter, G. C. (2006). *"Fuel flow method2" for estimating aircraft emissions*. 2006-01–1987. doi: 10.4271/2006-01-1987

ICAO. (n.d). *ICAO Aircraft Emissions Databank*. https://www.easa.europa.eu/en/domains/environment/icao-aircraft-engine-emissions-databank