IEc

Transitioning to Sustainable Aviation Fuel: Analysis of Air Quality Improvements and Human Health Benefits

Final Report | August 20, 2024

Prepared for:

Third Way
1025 Connecticut Ave NW
Washington, DC 20036

Prepared by:

Industrial Economics, Incorporated
2067 Massachusetts Avenue
Cambridge, MA 0214

With support from:

SC&A, Incorporated
2200 Wilson Blvd, Suite 300
Arlington, VA 22201-3324

Dr. Lance Sherry
Director, Air Transportation Systems Research Group
Co-Director, Center for Resilient and Sustainable Communities
Professor, System Engineering and Operations Research Dept.
George Mason University
4400 University Drive,
Fairfax, VA, 22030

Table of Contents

Executive Summary

This report assesses the health and air quality impacts of transitioning toward sustainable aviation fuels (SAF). This report modeled a scenario of SAF deployment on a net-zero trajectory to replace all domestic conventional jet fuel with SAF by 2050, a scenario consistent with the SAF Grand Challenge, a government-wide initiative to reduce the cost, increase sustainability, and expand production and use of these fuels.[1]

While SAF has clear climate benefits, widespread SAF adoption also reduces emissions of air pollutants affecting public health, including directly emitted fine particulate matter (direct PM) and sulfur dioxide (SO_2), a precursor for the formation of ambient $PM_{2.5}$ (Yakovlieva et al., 2019; Lobo et al., 2011). Because the production processes for SAF and conventional jet fuel differ, SAF adoption will also result in emissions changes associated with upstream activities that occur well prior to fuel combustion. These upstream changes affect emissions of $PM_{2.5}$ and its precursors including, SO_2, and oxides of nitrogen (NO_x), as well as ozone precursor emissions of NO_x and volatile organic compounds (VOCs).

The goal of this report is to quantify the impact of these emissions changes and to determine the associated national and local community health benefits, with a particular focus on airport communities in the United States.

We find that the full transition to SAF by 2050 results in public health benefits due to changes in both aviation fuel emissions and fuel production upstream emissions. From 2025 through 2050, we expect greater SAF use to result in 1,600 to 3,300 avoided premature deaths in total across the United States. Reductions in direct aviation emissions over this period further result in total monetized public benefits of $16 billion to $31 billion, while changes in four upstream pollutant emissions during fuel production result in $4.4 billion in monetized public health benefits cumulatively.[2] We calculate a present value grand total monetized public health benefit of $20 billion to $35 billion under the SAF scenario from 2025 through 2050 resulting from changes in aircraft emissions and upstream emissions.

[1] See additional details on the SAF Grand Challenge here: https://www.energy.gov/eere/bioenergy/sustainable-aviation-fuel-grand-challenge

[2] Numbers are discounted to 2023 using a discount rate of two percent.

Introduction

To mitigate the ongoing changes in climate that have resulted from anthropogenic emissions of greenhouse gases (GHGs), policymakers at multiple levels of government have begun to pursue or consider a variety of decarbonization strategies. A sector of particular interest to such strategies is the aviation sector. Civil aviation, including domestic and international flights, comprised nearly three percent of total U.S. CO_2 emissions in 2019, with over 97 percent of aviation CO_2 emissions related to jet fuel production and use. The aviation sector has already made substantial gains in fuel efficiency due to changes in business practices and technological improvements. From 1991 to 2019, U.S. air travel increased by 89 percent (measured by total enplanements), while fuel consumption increased by only 27 percent (FAA, 2019). As assessed in the Federal Aviation Administration's 2019 Aviation Climate Action Plan, further improvements in fuel efficiency will not fully meet the sector's further decarbonization need. Additional reductions in aviation sector emissions can be achieved through the increased use of sustainable aviation fuel (SAF) alternatives to conventional fossil jet fuel (FAA, 2019).

This report assesses the impact of SAF deployment on a net-zero trajectory within the aviation sector on fine particulate matter ($PM_{2.5}$) and on associated health outcomes. The SAF scenario evaluated adds the requirements established by the SAF Grand Challenge, a government-wide Memorandum of Understanding to reduce the cost, increase sustainability, and expand production and use of SAF.[3] The SAF scenario evaluates the SAF Grand Challenge targets of 1) supplying 3 billion gallons of SAF domestically by 2030, and 2) replacing all domestic jet fuel with SAF by 2050.[4] A transition to SAF use within the aviation sector will reduce emissions of directly emitted fine particulate matter (direct PM), as well as sulfur dioxide (SO_2), a precursor for the formation of secondary, ambient $PM_{2.5}$ (Yakovlieva et al., 2019; Lobo et al., 2011). While it is not expected that combustion of SAF will result in emissions reductions for nitrogen oxides (NO_x) and volatile organic compounds (VOCs), two ozone precursors, some ozone reductions are expected to result from the production of SAF. (Arter et al., 2022).

Additionally, this report assesses the impact of SAF deployment on the upstream emissions of four pollutants during SAF well-to-tank (WTT) production. Since the production processes for SAF and conventional jet fuel differ (e.g., SAF utilizes feedstock[5] while conventional jet fuel utilizes crude oil), SAF adoption will also result in emissions changes associated with activities that occur well prior to fuel combustion ("upstream" emissions). These upstream changes affect emissions of $PM_{2.5}$ and its precursors including, SO_2 and NO_x, as well as ozone precursor emissions of NO_x and VOCs. The SAF scenario evaluates changes in upstream emissions during the cultivation/procurement of feedstocks[6], transportation of feed to refineries, refinement of feed into fuel, and transportation of fuel to airports. The direction of change in pollutant emissions following SAF adoption will vary by year, pollutant, and WTT phase.

Ambient $PM_{2.5}$ and ozone pollution are both associated with increases in premature mortality and numerous non-fatal health effects. Ambient $PM_{2.5}$ consists of a mixture of inhalable solid particles and liquid aerosols that are smaller than 2.5 microns in diameter and able to penetrate deep into the lungs and enter the bloodstream. Exposure to $PM_{2.5}$ causes heart, lung, and other diseases, while exposure to ozone causes primarily respiratory

[3] See additional details on the SAF Grand Challenge here: https://www.energy.gov/eere/bioenergy/sustainable-aviation-fuel-grand-challenge

[4] Airlines for America 2021 news update: https://www.airlines.org/news/u-s-airlines-announce-3-billion-gallon-sustainable-aviation-fuel-production-goal/

[5] Feedstock is the raw material from which SAF is produced and capture any material that can be used for fuel production other than fossil-sources, such as plant oils, municipal waste, agricultural residues, etc. https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/saf-what-is-saf.pdf

[6] Feedstock is the raw material from which SAF is produced and capture any material that can be used for fuel production other than fossil-sources, such as plant oils, municipal waste, agricultural residues, etc. https://www.iata.org/contentassets/d13875e9ed784f75bac90f000760e998/saf-what-is-saf.pdf

illnesses, such as asthma, both of which result in increases in emergency department visits, hospitalizations, missed days of work and school, and deaths.

The goal of this report is to understand the public health benefits of transitioning to greater SAF use within the aviation sector. The remainder of the report is organized as follows:

- In Chapter 1, we present a national-level analysis in which we:
    - Quantify the impact of aircraft emissions reductions on ambient $PM_{2.5}$ following SAF implementation and estimate the associated health benefits.
    - Identify the airports experiencing the greatest aircraft emissions reductions from SAF transition and estimate the associated public health benefits near these facilities.
    - Monetize the public health benefits of upstream emissions changes associated with SAF production.
- In Chapter 2, we discuss the results of our analyses and note several uncertainties in the estimates.
- In the Appendices, we present additional results.

CHAPTER 1 | Benefits of Sustainable Aviation Fuel Adoption

In this chapter, we present our methodology for estimating the human health benefits of transitioning to SAF, including the approaches to estimating aircraft related $PM_{2.5}$ reductions, changes in upstream emissions during SAF production, quantifying the associated adverse health effects, and valuing these outcomes. We discuss the impact of the SAF proposal on precursor emissions levels from both SAF use by aircraft and SAF production, and how reductions in direct PM and SO_2 from aircraft emissions reduce the formation of secondary $PM_{2.5}$. We analyze the health benefits associated with reductions in ambient $PM_{2.5}$ from SAF use and present the resulting avoided premature mortality and morbidity effects at both the national scale and for a selection of airports. Lastly, we monetize the benefits, and disbenefits, of changes in upstream emissions during SAF production and calculate the total national public health benefits from both SAF production and SAF use following SAF adoption.

1.1 Approach

Broadly, our approach for assessing the public health benefits of SAF adoption involves (1) estimating the policy-induced change in emissions of precursors, (2) quantifying the associated reduction in ambient $PM_{2.5}$ where possible, (3) estimating the health benefits associated with reduced pollutant exposure, and (4) calculating the monetary value of the policy-related health benefits. These steps are described in greater detail below.

1.1.1 Aircraft Emissions Reductions Following Sustainable Aviation Fuel Transition

IEc team member SC&A modeled aircraft emission changes resulting from the SAF transition. As a first step, SC&A conducted a literature review to identify the pollutants addressed by switching from conventional jet fuel to SAF use in aircraft. Available literature suggests that transitioning to SAF reduces aircraft emissions of SO_2 and $PM_{2.5}$ (Yakovlieva et al., 2019; Lobo et al., 2011). In contrast, precursor pollutants for ground-level ozone, including NO_x and VOCs, are not likely to change during fuel combustion as the result of switching from conventional jet fuel to SAF (Arter et al., 2022).

To model the aircraft emissions reductions in SO_2 and direct PM in the SAF scenario, SC&A first determined county-level SAF fuel consumption in future years. This calculation involves use of projected state-level SAF consumption using the national projected increase in SAF use and state-level jet fuel demands provided by Evolved Energy Research, in five-year increments from 2025 through 2050. Since this assessment focuses on the pollutants emitted on the earth's surface (i.e., less than 3,000 feet above ground level), the total SAF consumption for each year is multiplied by 10 percent, the proportion of total fuel use that occurs in the landing/takeoff (LTO) cycle (FAA, 2015). State-level SAF consumption is then allocated to the county level using the proportion of the total county aircraft operations to total state aircraft operations calculated from FAA commercial and air taxi operations data (FAA, 2023).[7]

Next, SC&A used the FAA's Aviation Environmental Design Tool (AEDT)[8], which models aircraft performance to estimate fuel consumption, emissions, noise and air quality consequences. Specifically, SC&A used the AEDT to estimate the emissions resulting from conventional jet fuel for the most common commercial aircraft at ATL airport (the largest airport in the United States.).[9] This allowed SC&A to calculate fuel usage

[7] For example, in Jefferson County, Alabama, the total annual commercial and air taxi operations is 54,360, while the total annual commercial and air taxi operations for the state of Alabama is 128,688. The county-level SAF consumption in Jefferson County is then equal to Alabama SAF consumption * 42.2% (54,360 / 128,688). General aviation operations are excluded from these calculations.

[8] FAA AEDT available online at: https://aedt.faa.gov/

[9] AEDT estimates emissions from the most common commercial aircraft at ATL airport using the average nationwide taxi times.

rates and emissions per LTO cycle. From the AEDT output, SC&A calculated each pollutant's emissions factors for conventional jet fuel (tons per million British thermal units, mmbtu, of fuel used).

Finally, SC&A calculated the reduction in aviation emissions for each year and county by multiplying the SAF fuel consumption by the conventional jet fuel emissions factors and by the pollutant-specific emissions savings per gallon of SAF used. Using Lobo et al. (2011), SC&A assumes that each gallon of SAF used to replace conventional jet fuel results in SO_2 savings of 70 percent and direct $PM_{2.5}$ savings of 62 percent.

1.1.2 Ambient $PM_{2.5}$ Concentration Reductions from Aircraft Emissions

We utilized the U.S. Environmental Protection Agency's (EPA's) Co-Benefits Risk Assessment Health Impacts Screening and Mapping Tool (COBRA) to model the contribution of aviation emissions to ambient $PM_{2.5}$ in the contiguous United States. COBRA provides reduced-form estimates of how spatially gridded changes in air pollution emissions will impact ambient $PM_{2.5}$ (EPA, 2021). COBRA provides baseline levels emissions of multiple pollutants (NO_2, SO_2, NH_3, SOA, $PM_{2.5}$, and VOCs) for 3 years (2016, 2023, and 2028). It further allows users to develop scenarios by modifying emissions across 14 categories (called "tiers") to model how these changes affect air quality. COBRA then calculates changes in air quality between the baseline scenario (i.e., zero policy change) and the control scenario (i.e., with SAF adoption) using a source-receptor matrix to translate the various pollutant emissions changes into ambient $PM_{2.5}$ concentrations. We used COBRA to generate county-level estimates of ambient $PM_{2.5}$ concentrations (in $\mu g/m^3$) under the SAF scenario for five-year increments from 2025 through 2050.

We used COBRA's 2028 emissions inventory as a baseline emissions scenario.[10] To generate a post-transition emissions scenario, we deducted the SAF county-level aircraft emissions reductions for SO_2 and $PM_{2.5}$ from the baseline emissions for these precursor pollutants within Tier 12/3/99 ("off-highway, aircraft"). We created a post-transition emissions scenario for each of the five-year increments from 2025 through 2050. We used the COBRA outputs, which describe the change in $PM_{2.5}$ concentrations, to estimate the health effects associated with a transition to SAF from aviation emissions. Although COBRA can be used to estimate changes in health effects and the monetary value of these effects, we performed a separate health benefits analysis, described below, that leverages more recent and spatially resolved data inputs consistent with EPA's current methodologies for estimating the benefits of proposed regulations.

1.1.3 Assessing Health Benefits of Ambient PM2.5 Concentration Reductions from Aircraft Emissions

We used EPA's Environmental Benefits Mapping and Analysis Program – Community Edition (BenMAP-CE) version 1.5.8.29, an open-source program employed by U.S. EPA for their regulatory impact analyses (RIAs). We used BenMAP-CE to estimate the impact of $PM_{2.5}$ concentrations on morbidity and mortality health endpoints by assessing the difference in the risk of those endpoints under the baseline and control (i.e., policy) scenarios. BenMAP-CE relies on health impact functions to quantify the change in incidence of adverse health impacts stemming from changes in ambient pollutant concentrations:

$$\Delta y = y_o \cdot \left(1 - e^{-\beta \cdot \Delta PM}\right) \cdot Pop$$

where Δy is the change in the incidence of the adverse health effect, y_o is the baseline incidence rate for the health effect, beta (β) is a coefficient derived from a relative risk (RR) estimate for a specific exposure change

[10] Estimated benefits from a transition to SAF are not dependent on the selected emissions inventory, as emissions reductions are estimated in tons (rather than as a percent of total emissions) and the selected concentration-response functions are linear (i.e., not dependent on the starting point for $PM_{2.5}$ concentrations).

published in an epidemiological study, ΔPM is the change in concentration of fine particulate matter, and *Pop* is the exposed population.

The health impact function highlights the datasets required for our analysis: two air quality surfaces per analysis, one baseline and one post-transition; population; and baseline incidence rate of the health endpoint being evaluated (e.g, deaths from all causes per person per year). Following quantification of health effects, we valued these outcomes using available economic research, including a mix of willingness to pay (WTP) and cost of illness (COI) estimates. Collectively, these values capture the welfare losses associated with $PM_{2.5}$-attributable death and disease.[11] The datasets utilized to perform the health benefits assessment are consistent with recent EPA RIAs; we detail them in Table 1.1.

Table 1.1. Health Benefits Assessment Datasets Overview[12]

Data Type	Data Input Description	Data Source
Population	2010 U.S. Census, 12-km grid level. Projected through 2050 based on county-level forecasts from Woods & Poole (2015).	Woods & Poole (2015) See BenMAP User Manual for detailed source information.
Baseline Incidence	2015 county-level all-cause mortality incidence rates for ages 0-99. Projected through 2060 based on the U.S. Census Bureau projected national mortality rates. Mix of county-level and national incidence data for morbidity endpoints.	See BenMAP User Manual for detailed source information.
Concentration-Response Functions	EPA Standard Health Functions for mortality and morbidity from EPA's BenMAP-CE tool. Endpoints are identified through each pollutant's Integrated Science Assessment (ISA), an extensive literature review conducted by EPA on the relationship and causality of a health effect due to the pollutant	EPA Technical Support Document (TSD) (2023) EPA ISA for Particulate Matter (2022)
Valuation Functions	EPA Standard Valuation Functions for mortality and morbidity endpoints from EPA's BenMAP-CE tool. Functions include a mix of WTP and COI values, including the EPA's value per statistical life estimate.	EPA Technical Support Document (TSD) (2023)

Consistent with the U.S. EPA 2023 RIA for the Proposed $PM_{2.5}$ National Ambient Air Quality Standards (NAAQS), we assessed avoided premature mortality using two alternative long-term exposure mortality studies, Pope III et al. (2019) and Wu et al. (2020). Each study reflects a different cohort of participants, the National Health Interview Survey (NHIS) and the Medicare cohort, respectively, as well as different years of exposure

[11] WTP represents the willingness of individuals to pay for a good or service, such as a reduction in the annual risk of illness or death. COI estimates include the direct medical costs and lost earnings associated with illness. Generally, we prefer valuing adverse health outcomes using high quality WTP estimates relative to high quality COI estimates because WTP is thought to incorporate the "pain and suffering" associated with these outcomes. For example, valuing non-fatal cardiovascular hospitalizations using only medical expenditures and lost productivity (i.e., a COI-based approach) would ignore the intangible costs (pain, discomfort, dread) associated with these events. Despite our preference for WTP-based estimates, economic valuation research is limited for many endpoints, resulting in the use (by EPA and others) of COI-based estimates for most non-mortality endpoints.

[12] See the BenMAP-CE User Manual for additional input data details and methodologies. https://www.epa.gov/sites/default/files/2015-04/documents/benmap-ce_user_manual_march_2015.pdf

and participant follow-up periods. Therefore, we used the concentration-response functions developed from both health studies and present the results as alternative estimates for avoided premature mortality in our assessment.

We assessed the health benefits associated with the $PM_{2.5}$ concentration reductions from aircraft in five-year increments from 2025 through 2050, consistent with the aircraft emissions reduction and ambient concentration reduction methods. We calculated the annual health benefits for intermediate years by interpolating linearly between the five-year increments.

1.1.4 Upstream Emissions Changes Following Sustainable Aviation Fuel Adoption

IEc team member SC&A modeled upstream emissions changes associated with the well-to-tank (WTT) production of conventional jet fuel and SAF. These SAF emissions result from cultivating or procuring feedstocks, transporting feed to refineries via on-road vehicles, refining feed into fuel, and transporting fuel to airports. The four step WTT process was assessed as three phases, with the transportation of feed to refineries and transportation of fuel to airports combined into a single phase. Emissions due to land use changes were not included in this analysis. SC&A utilized DOE's GREET model to estimate the WTT emissions factors for four pollutants: VOC, NO_x, SO_x, and $PM_{2.5}$ (ANL, 2022).

SC&A modeled upstream emissions for three common SAF refinement processes: alcohol-to-jet (ATJ), Fischer-Tropsch (F-T), and hydrotreated esters and fatty acids (HEFA).[13] For each conversion process, SC&A calculated the average result of various feedstocks to provide a general overview of the impact of each process.[14] SC&A determined the percentage of total SAF consumption for each conversion process from 2025 through 2050 in five-year increments. The distribution of SAF consumption across the three conversion processes was then used to calculate the upstream emissions.

SC&A calculated the upstream emissions changes for each five-year increment from 2025 through 2050 as the difference between the projected SAF WTT emissions and the conventional jet fuel WTT emissions that would have otherwise been consumed. Ultimately, SC&A generated total upstream emissions changes for each of the four pollutants from each WTT phase (i.e., cultivation, transportation, and refinement) and for each five-year increment from 2025 through 2050 (72 results total: four pollutants * three WTT phases * six years). Upstream emissions changes were calculated at the national scale as they occur across multiple locations and cannot be distributed to the county level.

1.1.5 Assessing Health Benefits of Upstream Emissions Changes

Because upstream emissions changes were generated at the national level, we were unable to employ the county-level benefits methodology described in Section 1.1.3. Instead, we applied a monetized benefit per ton (BPT) to the calculated change in directly-emitted pollutants. BPT estimates represent an average estimate of the economic value of avoided cases of mortality and morbidity per ton of reduced emissions. We relied upon 2023 BPT estimates from the EPA's *Technical Support Document (TSD): Estimating the Benefit per Ton of Reducing Directly-Emitted* $PM_{2.5}$*,* $PM_{2.5}$ *Precursors and Ozone Precursors from 21 Sectors.*[15]

As detailed in Table 1.2, we relied upon the EPA's 2023 BPT estimates for three sectors that best align with the WTT processes of transportation of feed to refineries, refinement of feed to fuel, and transportation of fuel to airports. However, the 2023 EPA TSD did not include a sector that perfectly aligned with cultivating or procuring feedstocks. Therefore, we relied upon the "area source" sector results of EPA's previous 2018 *TSD:*

[13] The Fischer-Tropsch process includes both bio-gasification Fischer-Tropsch and Fischer-Tropsch liquids (also referred to as power-to-liquids).

[14] Conversion processes were found to have a greater impact on upstream emissions of fuel than the specific feedstocks used.

[15] https://www.epa.gov/system/files/documents/2021-10/source-apportionment-tsd-oct-2021_0.pdf

Estimating the Benefit per Ton of Reducing $PM_{2.5}$ Precursors from 17 Sectors.[16] The area sources sector captures a collection of emission sectors not otherwise specified, including agriculture, and best aligns with the cultivating or procuring feed process.

Table 1.2. Benefits per Ton Estimates by WTT Process and Pollutant ($2023, 2% Discount Rate)

	Upstream Pollutant	$PM_{2.5}$	SO_x	NO_x[1]		VOC
		EPA $PM_{2.5}$-Related Benefits			*EPA Ozone-Related Benefits*	
WTT Phase	**EPA TSD Sector**	*Directly emitted $PM_{2.5}$*	*SO_2*	*NO_x*	*NO_x*	*VOC*
Cultivating or procuring feedstocks	Area sources[2]	$463,944	$71,580	$11,400		
Refinement of feed into fuel	Refineries	$439,949	$60,954	$27,650	$133,951	$75,086
Transportation of 1) feed to refineries via on-road vehicles & 2) fuel to airports via pipelines	Internal Combustion Engines (ICE) & Oil and natural gas transmission[3]	$183,107	$40,984	$14,685	$89,772	$75,701

Notes:

1. *NO_x is a precursor emission for both ambient $PM_{2.5}$ and ozone. Therefore, the NO_x benefits are calculated using the sum of both precursor BPT estimates.*
2. *The 2018 EPA BPT TSD does not estimate ozone-related benefits. Therefore, BPT values for ozone-related benefits from NO_x and VOC emissions during cultivation/procurement of feedstock is not available for assessment.*
3. *The transportation BPT is an average of the two sectors, Internal Combustion Engines (ICE) and Oil and natural gas transmission, that align with the two forms of transportation during the WTT SAF process.*

Of the four pollutants assessed, two pollutants ($PM_{2.5}$ and SO_x) are precursor emissions for ambient $PM_{2.5}$, one pollutant (VOC) is a precursor emission for ozone, and one pollutant (NO_x) is a precursor emission for both ambient $PM_{2.5}$ and ozone. We calculated the monetized health benefits by applying the emission-specific BPT to the total emissions changes resulting from each WTT process in five-year increments from 2025 through 2050, consistent with the methods for determining the upstream emissions changes.

1.2 National Benefits of SAF Adoption from Aircraft Emissions

Transitioning to SAF reduces both direct PM and SO_2 emissions from aircraft, both precursors for the formation of ambient $PM_{2.5}$. We modeled how aircraft pollutant emissions, and the resulting ambient $PM_{2.5}$ levels, will change during the SAF transition from 2025 through 2050 in five-year increments. As presented in Table 1.3, the national reductions in both direct PM and SO_2 aviation emissions are expected to grow from 2025 through 2050, with the reduction in aviation emissions increasing 30-fold by 2050.

Table 1.3. Total National Aircraft Emissions Reductions following SAF Adoption

Pollutant	2025	2030	2035	2040	2045	2050
*Percent SAF adoption**	1.8%	5.1%	20%	51%	77%	100%

[16] https://www.epa.gov/sites/default/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf

Tons of Direct PM	19	125	303	411	505	621
Tons of SO_2	232	1,529	3,700	5,009	6,161	7,577

**Per the International Air Transport Association, 2023 Net zero 2050: sustainable aviation fuels fact sheet:: https://www.iata.org/en/iata-repository/pressroom/fact-sheets/fact-sheet---alternative-fuels/*

When focusing on the counties containing the top 200 busiest airports, the reduction in precursor emissions translates to a population-weighted average reduction in ambient $PM_{2.5}$ concentrations of 0.01 µg/m^3 by 2050, shown in Table 1.4. The national county-level $PM_{2.5}$ concentration reductions are presented for 2035 and 2050 in Figure 1.1Figure 1.1. 2035 $PM_{2.5}$ reductions from SAF and Figure 1.2. Overall, $PM_{2.5}$ reductions from increased SAF use are greatest in metropolitan areas, including Los Angeles, New York City, Chicago, Houston, and Miami. This spatial distribution of air quality improvements reflects how aviation activities are often concentrated near metropolitan areas.

Table 1.4. Population-Weighted Average Reductions in Ambient $PM_{2.5}$ from SAF Use

	$PM_{2.5}$ Concentration (µg/m^3)					
Exposure	**2025**	**2030**	**2035**	**2040**	**2045**	**2050**
National	0.0002	0.0013	0.0031	0.0042	0.0052	0.0063
Counties containing commercial* airports	0.0002	0.0015	0.0035	0.0047	0.0058	0.0071
Counties containing top 200 busiest airports	0.0003	0.0020	0.0048	0.0064	0.0079	0.0096
Counties containing top 50 busiest airports	0.0004	0.0028	0.0068	0.0091	0.0111	0.0136

**Commercial airports are defined by the FAA as publicly owned airports that have at least 2,500 passenger boardings each calendar year and receive scheduled passenger services. Passenger boardings are boardings receiving revenue.*

Figure 1.1. 2035 $PM_{2.5}$ reductions from SAF Use

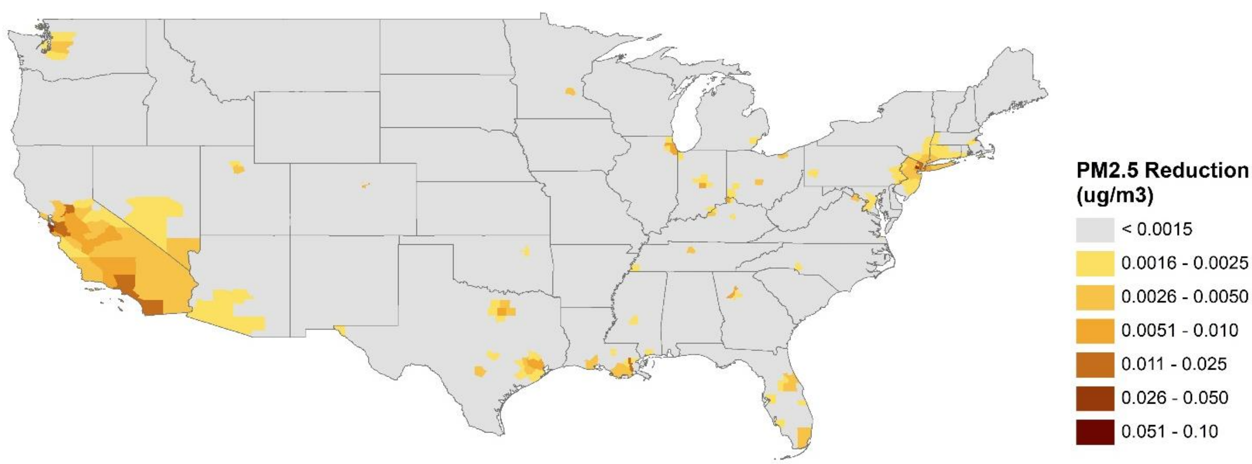
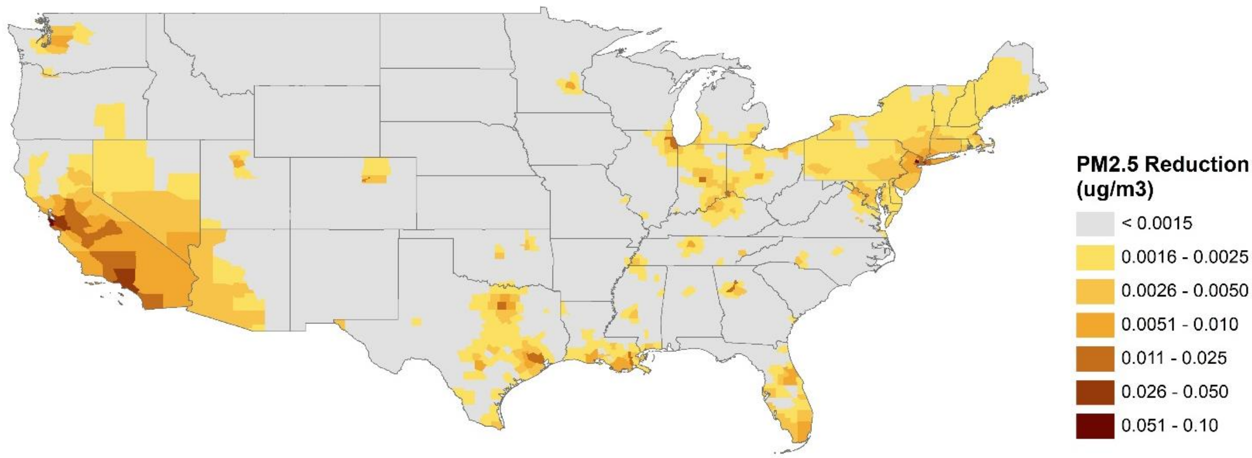


Figure 1.2. 2050 $PM_{2.5}$ reductions from SAF Use



1.2.1 Health Benefits Results from SAF Use (Aircraft Emissions)

As described in Section 1.1.3, we assessed health benefits of aircraft emissions changes under the SAF scenario using two alternative avoided premature mortality health impact functions for $PM_{2.5}$, Pope III et al. (2019) and Wu et al. (2020). These two estimates are not additive but rather represent alternative $PM_{2.5}$-mortality relationships estimated in recent epidemiological literature. For the remainder of this report, we present our results as a range between the two mortality estimates. We emphasize that EPA does not provide greater weight to either study. We present benefit results for a mid-point year (2035), the end year (2050), and the cumulative period (2025-2050).

The estimated $PM_{2.5}$-related health benefits associated with SAF use are summarized in Table 1.5. The SAF scenario results in a total of 1,600 to 3,300 avoided premature deaths, cumulatively from 2025 through 2050.

Table 1.5. National Health Effects Results from SAF Use (rounded to two significant figures)

Benefits Estimate	Year 2035	Year 2050	Total (2025 – 2050)
Mortality-related benefits - Pope III et al. 2019 (18-99)	110	260	3,300
Mortality-related benefits - Wu et al., 2020 (65-99)	52	130	1,600
Select Non-Fatal Health Effects			
New Onset Asthma (0-17)	*130*	*280*	*3,900*
ER Visits, Respiratory (0-99)	*31*	*70*	*930*
Incidence, Non-Fatal Lung Cancer (30-99)	*4.1*	*10*	*130*
Hospitalizations, Cardiovascular Disease (65-99)	*8.3*	*21*	*260*
Incidence, Stroke (65-99)	*3.4*	*8.1*	*100*

Presented in Table 1.6, the monetized public health benefits, including benefits from avoided non-fatal health effects, are estimated to be \$0.70 to \$1.4 billion in 2035 and \$1.9 to \$3.7 billion in 2050. The total cumulative monetized public health benefits from 2025 through 2050 correspond to a present value of $16 billion to $31 billion, when discounted to 2023 using a discount rate of two percent. The majority (99 percent) of monetized benefits are attributable to avoided premature deaths.

Table 1.6. National Monetized Benefits Results from SAF Use (rounded to two significant figures, Billions $2023)

Benefits Estimate	Year 2035	Year 2050	Total (2025 – 2050)	Present Value (2025 – 2050)
	Undiscounted[1]			*2% Discount Rate*[2]
Avoided $PM_{2.5}$-related premature deaths using Pope III et al., 2019, plus associated morbidities	**$1.4**	**$3.7**	**$46**	**$31**
Avoided non-fatal effects	*$0.015*	*$0.033*	*$0.45*	*$0.3*
Avoided premature mortality	*$1.4*	*$3.7*	*$45*	*$31*
Avoided $PM_{2.5}$-related premature deaths using Wu et al., 2020, plus associated morbidities	**$0.7**	**$1.9**	**$23**	**$16**
Avoided non-fatal effects	*$0.015*	*$0.033*	*$0.45*	*$0.3*
Avoided premature mortality	*$0.69*	*$1.9*	*$23*	*$15*

Notes:

1. *Valuation of premature mortality within BenMAP-CE applies a 20-year cessation lag with a discount rate of two percent.*
2. *Present Value is discounted to year 2023 at a two percent discount rate, consistent with the recommendations of the White House Office of Management and Budget's Circular A-4 (2023)*

Figure 1.3 and 1.4 display the distribution of avoided deaths per 100,000 people resulting from increased SAF use across counties within the United States. The three counties experiencing the highest avoided premature mortality per 100,000 people are San Mateo, California; Essex, New Jersey, and Los Angeles, California.

Figure 1.3. Avoided Deaths per 100,000 in 2035

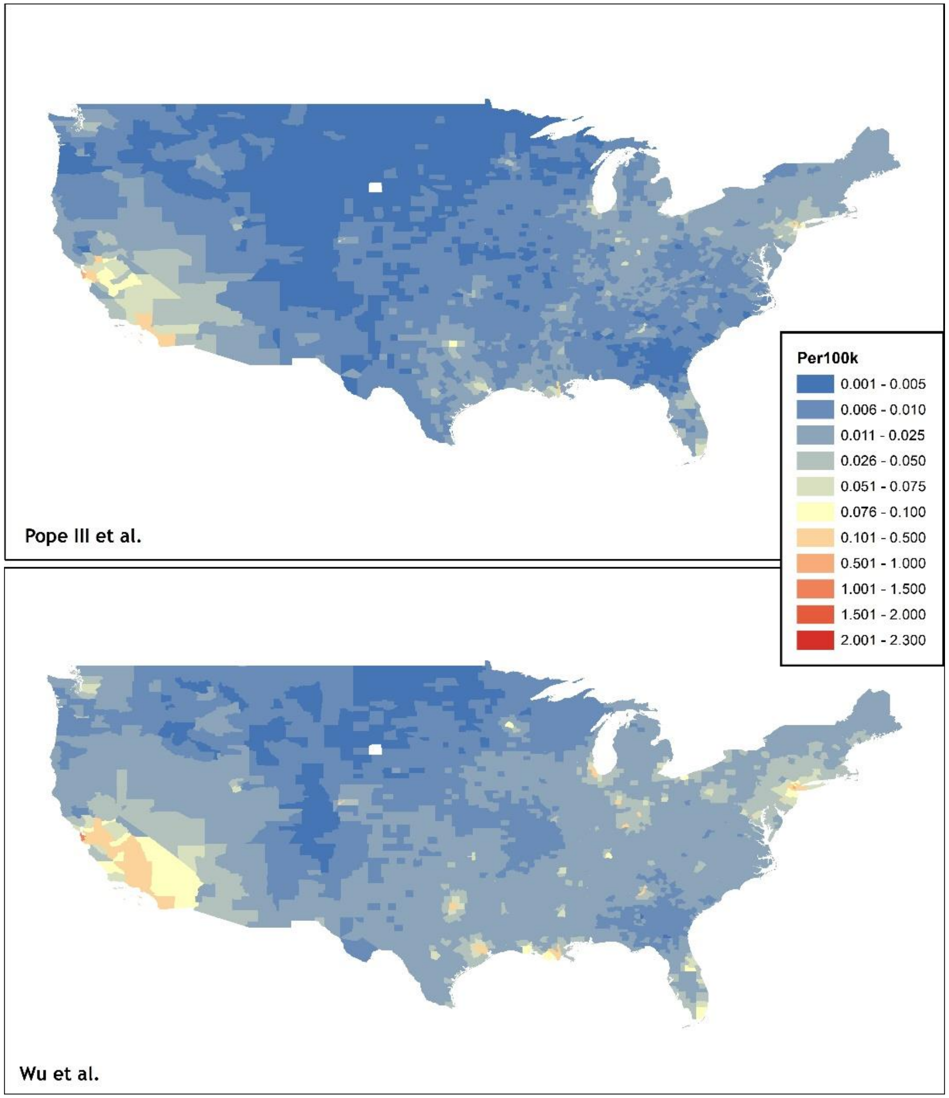
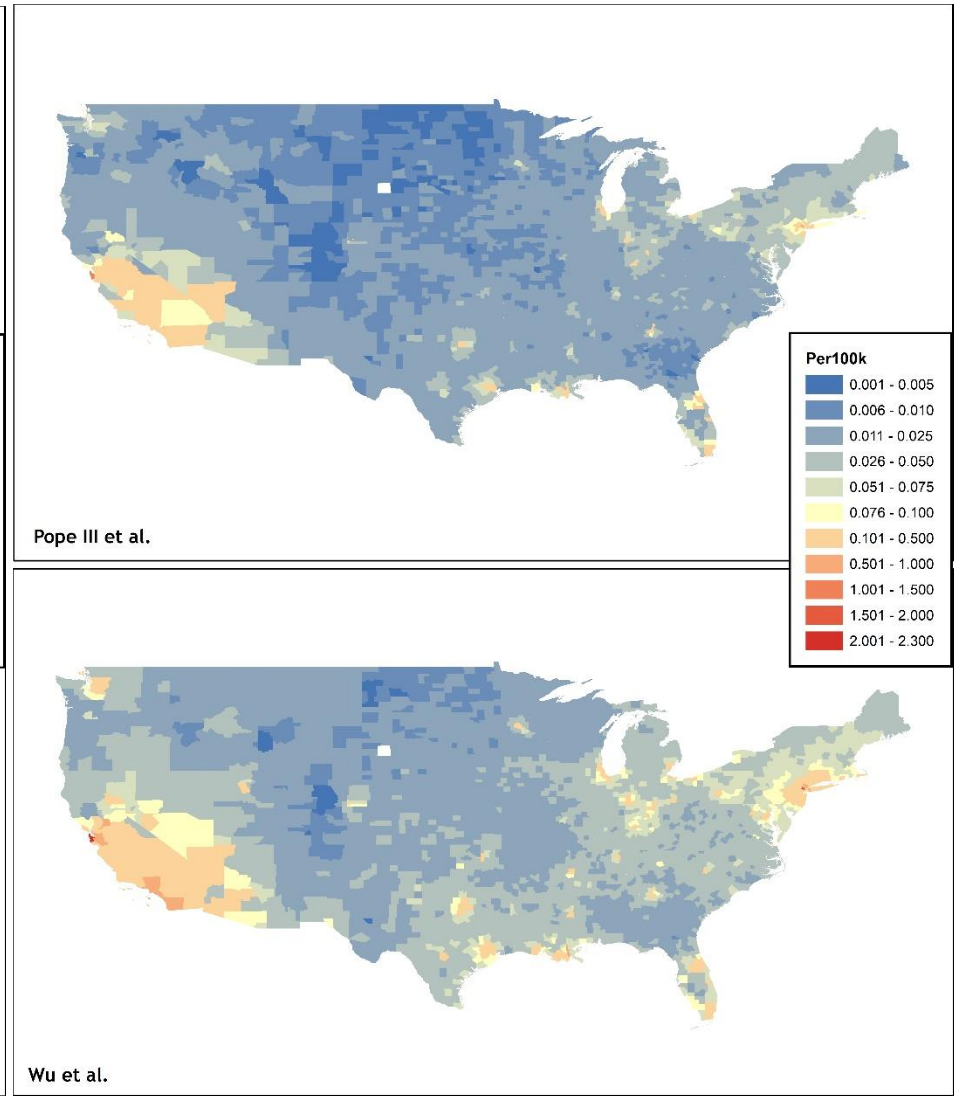


Figure 1.4. Avoided Deaths per 100,000 in 2050

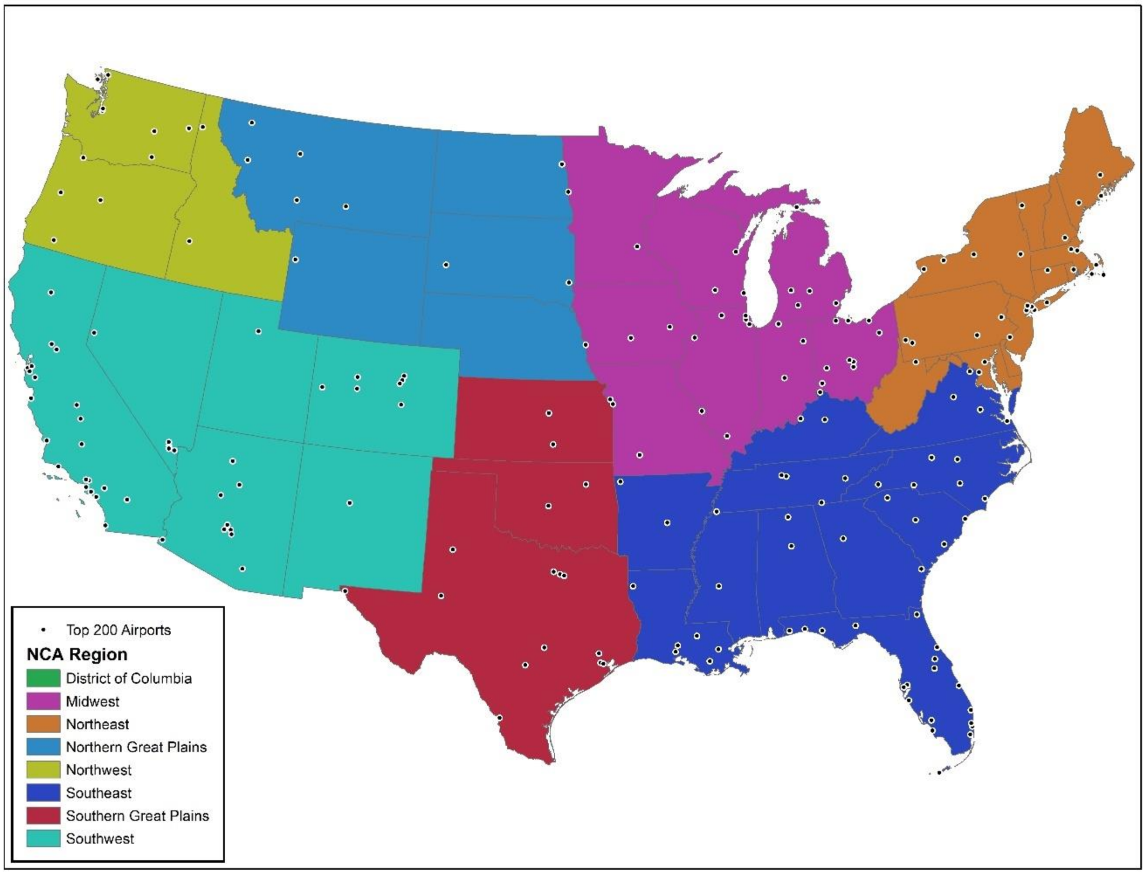


Note: There is one county, Shannon, South Dakota, for which COBRA does not include emissions data and for which health benefits are not estimated.

1.3 Benefits of SAF Adoption from Aircraft Emissions at Select Airports

To supplement the national assessment of aircraft emissions changes under the SAF scenario, we assessed the impact of aircraft emission reductions on populations near the top 200 busiest airports in the contiguous United States. We identified these airports using FAA commercial and air taxi operations data (FAA, 2023). To characterize the selected airport level emissions reductions, we distributed the county-level $PM_{2.5}$ and SO_2 aircraft emissions reduction to each of the selected airports using the ratio of the airport's commercial and air taxi operations to their respective county's total commercial and air taxi operations. A map of the selected airports, which make up 84 percent of the national aircraft emissions reductions under the SAF scenario, is presented in Figure 1.5.

Figure 1.5. Top 200 Busiest Airport Selections by National Climate Assessment (NCA) Region



To model the airport level contribution to ambient $PM_{2.5}$ reductions, the airport level emissions reductions were each run through COBRA using the same methodology outlined in Section 1.1.2. COBRA generates county-level estimates of changes to $PM_{2.5}$ concentrations; however, we restricted the pollutant concentration reductions assessed to those within a 10-kilometer buffer of the airports. By using a 10-kilometer buffer, we captured the populations nearest the airports, i.e., those most likely to be affected by the SAF transition. A 10-kilometer buffer is consistent with the methodology of various studies concerning the impact of aircraft pollutants on nearby communities (Chung et al., 2013; Hudda et al., 2018; Lawal et al., 2022). We assessed the health benefits of the selected airports' ambient $PM_{2.5}$ concentration reductions using the same methodology described in Section 1.1.3.

1.3.1 Health Benefits Results from SAF Use for the Top 200 Busiest Airports

Consistent with Section 1.2, we assessed health benefits of aircraft emissions changes under the SAF scenario using two alternative avoided premature mortality functions, Pope III et al. (2019) and Wu et al. (2020). We present our results as a range between the two mortality estimates. We emphasize that EPA does not provide greater weight to either study.

The estimated $PM_{2.5}$-related health benefits associated with greater SAF use at the top 200 busiest airports are summarized in Table 1.7. The SAF scenario within 10 km of the selected airports results in a total of 360 to 730 avoided premature deaths cumulatively from 2025 through 2050, accounting for one-fifth of the total national benefits.

Table 1.7. Health Effects Results from SAF Use at the Top 200 Busiest Airports (rounded to two significant figures)

Benefits Estimate	Year 2035	Year 2050	Total (2025 – 2050)
Mortality-related benefits - Pope III et al. 2019 (18-99)	24	56	730
Mortality-related benefits - Wu et al., 2020 (65-99)	11	29	360
Select Non-Fatal Health Effects			
New Onset Asthma (0-17)	31	66	900
ER Visits, Respiratory (0-99)	7.3	16	220
Incidence, Non-Fatal Lung Cancer (30-99)	0.97	2.3	30
Hospitalizations, Cardiovascular Disease (65-99)	1.8	4.6	58
Incidence, Stroke (65-99)	0.78	1.9	24

Presented in Table 1.8, the monetized public health benefits, including benefits from avoided non-fatal health effects, are estimated to be \$160 to \$320 million in 2035 and \$420 to \$820 million in 2050. The total cumulative monetized public health benefits from 2025 through 2050 correspond to a present value of \$3.4 billion to \$6.9 billion, when discounted to 2023 using a discount rate of two percent. The majority (99 percent) of monetized benefits are attributable to avoided premature deaths.

Table 1.8. Monetized Benefits Results from SAF Use at the Top 200 Busiest Airports (rounded to two significant figures, Billions $2023)

Benefits Estimate	Year 2035	Year 2050	Total (2025 – 2050)	Present Value (2025 – 2050)
		Undiscounted[1]		*2% Discount Rate*[2]
Avoided $PM_{2.5}$-related premature deaths using Pope III et al., 2019, plus associated morbidities	**$0.32**	**$0.82**	**$10**	**$6.9**
Avoided non-fatal effects	*$0.0036*	*$0.008*	*$0.11*	*$0.073*
Avoided premature mortality	*$0.31*	*$0.81*	*$10*	*$6.8*
Avoided $PM_{2.5}$-related premature deaths using Wu et al., 2020, plus associated morbidities	**$0.16**	**$0.42**	**$5.1**	**$3.4**
Avoided non-fatal effects	*$0.0036*	*$0.008*	*$0.11*	*$0.073*
Avoided premature mortality	*$0.15*	*$0.41*	*$5.0*	*$3.4*

Notes:

1. *Valuation of premature mortality within BenMAP-CE applies a 20-year cessation lag with a discount rate of two percent.*
2. *Present Value is discounted to year 2023 at a two percent discount rate, consistent with the recommendations of the White House Office of Management and Budget's Circular A-4 (2023)*

Table 1.9 and Table 1.10 present the top 25 airports accounting for total avoided premature deaths resulting from SAF use during the SAF transition.

Table 1.9. Avoided Premature Deaths from SAF Use at the Top 25 Busiest Airports using Pope III et al., 2019 (rounded to two significant figures, monetized in millions $2023)

Airport Name	Total Avoided Deaths (2025 – 2050)	Total Monetary Value Including Non-fatal Effects (2025-2050) *Undiscounted*[1]	Present Value Including Non-fatal Effects (2025-2050) *2% Discount Rate*[2]
San Francisco International	86	$1,200	$810
Los Angeles International	81	$1,100	$770
Newark Liberty International	52	$730	$500
John Wayne/Orange County	48	$670	$450
Norman Y Mineta San Jose International	36	$510	$340
Metro Oakland International	36	$500	$340
San Diego International	30	$430	$280
John F Kennedy International	25	$360	$240
LaGuardia	23	$330	$220
Ronald Reagan Washington National	23	$320	$210
Louis Armstrong New Orleans International	16	$230	$150
Dallas-Fort Worth International	14	$200	$130
Chicago O'Hare International	13	$180	$130
George Bush Intercontinental/Houston	12	$170	$120
Teterboro	12	$160	$110
Bob Hope	11	$150	$100
Orlando International	10	$150	$97
General Edward Lawrence Logan International	9.9	$140	$94
San Antonio International	9.4	$130	$89
Louisville Muhammad Ali International	9.1	$130	$86
Chicago Midway International	8.4	$120	$80
Sacramento International	7.6	$110	$72
Minneapolis-St Paul International/Wold-Chamberlain	6.6	$93	$63
Philadelphia International	6.4	$90	$61
Indianapolis International	5.9	$83	$57

Notes:

1. *Valuation of premature mortality within BenMAP-CE applies a 20-year cessation lag with a discount rate of two percent.*
2. *Present Value is discounted to year 2023 at a two percent discount rate, consistent with the recommendations of the White House Office of Management and Budget's Circular A-4 (2023)*

Table 1.10. Avoided Premature Deaths from SAF Use at the Top 25 Busiest Airports using Wu et al., 2020 (rounded to two significant figures, monetized in millions $2023)

Airport Name	Total Avoided Deaths (2025 – 2050)	Total Monetary Value Including Non-fatal Effects (2025-2050) *Undiscounted*[1]	Present Value Including Non-fatal Effects (2025-2050) *2% Discount Rate*[2]
San Francisco International	44	$630	$420
Los Angeles International	40	$570	$390
John Wayne/Orange County	25	$350	$230
Newark Liberty International	24	$350	$240
Norman Y Mineta San Jose International	18	$260	$180
Metro Oakland International	18	$250	$170
San Diego International	16	$220	$150
John F Kennedy International	13	$180	$120
LaGuardia	11	$160	$110
Ronald Reagan Washington National	11	$160	$110
Louis Armstrong New Orleans International	7.7	$110	$74
Dallas-Fort Worth International	6.7	$96	$65
Chicago O'Hare International	6.5	$91	$62
Teterboro	6.0	$84	$57
George Bush Intercontinental/Houston	5.5	$80	$53
Bob Hope	5.4	$77	$52
Orlando International	5.3	$76	$50
General Edward Lawrence Logan International	4.8	$68	$46
San Antonio International	4.6	$65	$44
Louisville Muhammad Ali International	4.3	$61	$42
Chicago Midway International	4.1	$58	$39
Sacramento International	3.7	$53	$36
Minneapolis-St Paul International/Wold-Chamberlain	3.4	$48	$32
Philadelphia International	3.0	$43	$29
Fort Lauderdale/Hollywood International	2.8	$39	$26

Notes:

1. *Valuation of premature mortality within BenMAP-CE applies a 20-year cessation lag with a discount rate of two percent.*
2. *Present Value is discounted to year 2023 at a two percent discount rate, consistent with the recommendations of the White House Office of Management and Budget's Circular A-4 (2023)*

1.4 National Benefits of SAF Adoption from Upstream Emissions

Transitioning to SAF use in the aviation sector reduces aircraft emissions that are precursors for the formation of ambient $PM_{2.5}$. In order to fully understand the benefits of SAF adoption, we must also assess the impact of SAF production on upstream pollutant emissions. We modeled how four pollutant emissions will change during SAF production following the transition to SAF use from 2025 through 2050 in five-year increments. Table 1.11 presents the total tons of pollutants emitted during SAF production, as well as the total tons of pollutants emitted during conventional jet fuel production for the equivalent amount of fuel that would have otherwise been consumed. As shown in Table 1.11, the net emission change varies in magnitude and direction by year and pollutant. Transitioning to SAF will generally result in an overall decrease in upstream $PM_{2.5}$, SO_x, and VOC emissions, while resulting in an overall increase in upstream NO_x emissions.

Table 1.11. Total National Upstream Emissions by Conversion Process following SAF Adoption

		Tons of Emissions			
Year	Fuel Type	$PM_{2.5}$	SO_x	NO_x	VOC
2025	Sustainable Aviation Fuel	92	283	1,870	534
	Conventional Jet Fuel	33	72	266	173
	Net Emission Change	**60**	**212**	**1,605**	**361**
2030	Sustainable Aviation Fuel	172	533	3,718	843
	Conventional Jet Fuel	216	474	1,754	1,141
	Net Emission Change	**-44**	**59**	**1,963**	**-298**
2035	Sustainable Aviation Fuel	231	752	5,191	938
	Conventional Jet Fuel	522	1,146	4,245	2,760
	Net Emission Change	**-291**	**-393**	**947**	**-1,822**
2040	Sustainable Aviation Fuel	349	888	8,861	1,197
	Conventional Jet Fuel	707	1,551	5,745	3,736
	Net Emission Change	**-358**	**-663**	**3,116**	**-2,539**
2045	Sustainable Aviation Fuel	791	1,074	23,362	2,323
	Conventional Jet Fuel	869	1,907	7,067	4,595
	Net Emission Change	**-78**	**-834**	**16,295**	**-2,272**
2050	Sustainable Aviation Fuel	1,456	1,219	44,936	3,805
	Conventional Jet Fuel	1,069	2,346	8,691	5,651
	Net Emission Change	**387**	**-1,126**	**36,245**	**-1,846**
Total Emission Change (2025-2050)		**-2,510**	**-11,896**	**225,152**	**-39,112**

Although the total emission change is large for some pollutants, such as NO_x, the magnitude of benefits or disbenefits due to these changes is heavily dependent upon the projected emissions change for each WTT phase. This is due to the variation in BPT by sector, or WTT phase, which captures variations in 1) proximity of the pollutant source to populations, 2) geographic distribution of source locations, and 3) source release parameters (e.g, stack height) (EPA, 2018). As shown in Table 1.12, the refinement phase is the largest contributor to emission changes for $PM_{2.5}$, SO_x, and VOC, while feedstock cultivation/procurement is the largest contributor to NO_x emission changes.

Table 1.12. Total National Upstream Emissions Changes by WTT Phase following SAF Adoption

		Tons of Emissions Change			
Year	**Conversion Process**	**$PM_{2.5}$**	**SO_x**	**NO_x**	**VOC**
2025	Feedstock	54	206	1,114	481
	Refinement	3	17	235	-146
	Transportation	3	-11	257	26
	Net Emission Change	**60**	**212**	**1,605**	**361**
2030	Feedstock	86	304	1,861	724
	Refinement	-135	-228	-335	-1,067
	Transportation	5	-16	437	45
	Net Emission Change	**-44**	**59**	**1,963**	**-298**
2035	Feedstock	93	312	2,031	751
	Refinement	-389	-689	-1,565	-2,623
	Transportation	5	-17	481	49
	Net Emission Change	**-291**	**-393**	**947**	**-1,822**
2040	Feedstock	172	318	4,329	904
	Refinement	-542	-966	-2,307	-3,560
	Transportation	12	-15	1,093	118
	Net Emission Change	**-358**	**-663**	**3,116**	**-2,539**
2045	Feedstock	547	371	15,192	1,670
	Refinement	-671	-1,197	-2,884	-4,382
	Transportation	46	-7	3,987	439
	Net Emission Change	**-78**	**-834**	**16,295**	**-2,272**
2050	Feedstock	1,127	359	31,525	2,621
	Refinement	-840	-1,506	-3,734	-5,398
	Transportation	101	21	8,454	931
	Net Emission Change	**387**	**-1,126**	**36,245**	**-1,846**
Total (2025-2050)	Feedstock	8,030	8,215	214,981	29,551
	Refinement	-11,192	-19,866	-45,950	-74,789
	Transportation	652	-245	56,121	6,126
	Net Emission Change	**-2,510**	**-11,896**	**225,152**	**-39,112**

1.4.1 Health Benefits Results from SAF Production

As described in Section 1.1.5, we assessed health benefits of SAF production for each WTT phase by applying the EPA's respective sector BPT values from the 2023 TSD and 2018 TSD. The resulting benefits of each phase represent the economic value of avoided, or added, cases of mortality and morbidity from emissions changes. Since we assessed upstream emissions changes for precursors of both $PM_{2.5}$ (direct PM, SO_x, and NO_x) and ozone (NO_x and VOCs), we estimated the public health benefits of both $PM_{2.5}$ and ozone. We present results for each upstream pollutant, rather than the ambient secondary pollutant (i.e., $PM_{2.5}$ and ozone). For upstream pollutants that are precursors of both $PM_{2.5}$ and ozone (i.e., NO_x), the monetized benefits are calculated as the total of the $PM_{2.5}$- and ozone-related benefits.

The monetized health benefits associated with SAF production following SAF adoption are summarized in Table 1.13. The monetized public health benefits and disbenefits, including non-fatal health effects, for all pollutants are estimated to be $400 million in 2035 and -$240 million in 2050. The primary drivers for the disbenefits in 2050 are the projected increase in $PM_{2.5}$ and NO_x emissions during feedstock production and the projected increase in NO_x emissions during the transportation of feedstock and fuel.

The total cumulative monetized public health benefits from 2025 through 2050 correspond to a present value of $4.4 billion, when discounted to 2023 using a discount rate of two percent. These results largely reflect a decrease in emissions associated with refining; however, we observe increased emissions associated with cultivating or procuring feedstocks and transporting the resulting SAF (relative to conventional jet fuel).

Table 1.13. Monetized Benefits Results of SAF Production (rounded to two significant figures, Millions $2023)

Year	Conversion Process	Pollutant				Total	Present Value
		$PM_{2.5}$	SO_x	NO_x[1]	VOC[2]	*Undiscounted*[3]	*2% Discount Rate*[4]
2035	Feedstock	-$43	-$22	-$23	N/A	-$89	-$68
	Refinement	$170	$42	$250	$200	$660	$510
	Transportation	-$0.95	$0.68	-$50	-$3.7	-$54	-$42
	Total	**$130**	**$20**	**$180**	**$190**	**$520**	**$400**
2050	Feedstock	-$520	-$26	-$360	N/A	-$910	-$520
	Refinement	$370	$92	$600	$410	$1,500	$840
	Transportation	-$19	-$0.85	-$880	-$70	-$970	-$560
	Total	**-$170**	**$65**	**-$640**	**$330**	**-$410**	**-$240**
Total (2025-2050)	Feedstock	-$3,700	-$590	-$2,500	N/A	-$6,800	-$4,400
	Refinement	$4,900	$1,200	$7,400	$5,600	$19,000	$13,000
	Transportation	-$120	$10	-$5,900	-$460	-$6,400	-$4,100
	Total	**$1,100**	**$630**	**-$890**	**$5,200**	**$6,000**	**$4,400**

Notes:

1. *NO_x is a precursor emission for both ambient $PM_{2.5}$ and ozone. Therefore, the NO_x benefits are calculated using the sum of both precursor BPT estimates.*
2. *The 2018 EPA BPT TSD does not estimate ozone-related benefits. Therefore, BPT values for ozone-related benefits from NO_x and VOC emissions during feedstock phase is not assessed*
3. *Valuation of premature mortality within the BPT utilized applies a 20-year cessation lag with a discount rate of two percent.*
4. *Present Value is discounted to year 2023 at a two percent discount rate, consistent with the recommendations of the White House Office of Management and Budget's Circular A-4 (2023).*

1.5 Total Benefits of SAF Adoption

The transition to SAF replacement of all domestic jet fuel by 2050 results in public health benefits associated with changes in emissions from aviation activities and upstream production. Reductions in ambient $PM_{2.5}$ concentrations following reductions in aviation emissions result in a total of 1,600 to 3,300 avoided premature deaths, cumulatively from 2025 through 2050, valued at $16 billion to $31 billion, when discounted to 2023 using a discount rate of two percent. Changes in four upstream pollutant emissions during fuel production result in $4.4 billion in cumulative monetized public health benefits from 2025 through 2050, when discounted to 2023 using a discount rate of two percent.

We calculate a present value grand total monetized public health benefit of $20 billion to $35 billion under the SAF scenario from 2025 through 2050 resulting from changes in aircraft emissions and upstream emissions (Table 1.14).

Table 1.14. National Monetized Benefits Results (rounded to two significant figures, Billions $2023)

Emissions Change	Benefits Estimate	Year 2035	Year 2050	Total (2025 – 2050)	Present Value (2025 – 2050)
		Undiscounted[1]			*2% Discount Rate*[2]
Aircraft	Avoided $PM_{2.5}$-related premature deaths (Pope III et al., 2019), plus associated morbidities	$1.4	$3.7	$46	$31
	Avoided $PM_{2.5}$-related premature deaths (Wu et al., 2020), plus associated morbidities	$0.7	$1.9	$23	$16
Upstream		$0.52	-$0.41	$6.0	$4.4
Total	**Avoided $PM_{2.5}$-related premature deaths (Pope III et al., 2019), plus associated morbidities**	**$1.9**	**$3.3**	**$52**	**$35**
	Avoided $PM_{2.5}$-related premature deaths (Wu et al., 2020), plus associated morbidities	**$1.2**	**$1.5**	**$29**	**$20**

Notes:

1. *Valuation of premature mortality within BenMAP-CE applies a 20-year cessation lag with a discount rate of two percent.*
2. *Present Value is discounted to year 2023 at a two percent discount rate, consistent with the recommendations of the White House Office of Management and Budget's Circular A-4 (2023)*

CHAPTER 2 | Discussion

In this report, we presented the impact of emissions reductions in the aviation sector on ambient $PM_{2.5}$ concentrations and upstream pollutant emissions following a transition from conventional jet fuel usage to SAF usage through 2050. We also present the resulting health benefits as avoided cases and as monetized values.

When assessing aviation emissions, we find that SO_2 and direct PM emissions decrease from 2025 through 2050, resulting in a population-weighted average reduction in $PM_{2.5}$ concentrations in the counties containing the top 200 busiest airports of 0.01 $\mu g/m^3$ by 2050. These improvements in air quality result in considerable improvements to human health. We estimate the SAF transition scenario will avoid a cumulative total of 1,600 to 3,300 premature deaths through 2050. Combined with the avoided non-fatal health effects, we estimate national benefits of between $16 billion to $31 billion in present value terms. When assessing the impact of the SAF scenario on populations within a 10-kilometer perimeter of the top 200 busiest airports in the contiguous United States, we estimate the monetized benefits for these selected airports correspond to a present value of $3.4 billion to $6.9 billion.

Avoided premature deaths comprise 99 percent of the monetized health benefits for the national and airport-specific results, but we emphasize that the benefits of avoided non-fatal health effects are also substantial. The SAF scenario results in present value public health benefits of $300 million and $73 million when considering only non-fatal outcomes for the national and airport-specific assessments, respectively. A few examples of avoided non-fatal health effects associated with reductions in $PM_{2.5}$ concentrations include: new onset asthma, hospitalizations due to Alzheimer's disease, non-fatal lung cancer, and hospitalizations due to cardiovascular illness.

The aviation emissions results are broadly consistent with available literature. For example, Burnelle-Yeung et al. (2014) estimated that landing and takeoff emissions in the contiguous United States are responsible for 210 (130 to 340, 90% C.I.) aviation-attributable deaths per year. On average, our results estimate 63 to 130 annually avoided premature deaths following SAF adoption. We expect our estimates to be lower than the burden estimated by Brunelle-Yeung et al. (2014) as our analysis reflects only a reduction in emissions rather than 100 percent of all aviation emissions.

When assessing upstream emissions changes due to SAF production, we find that from 2025 through 2050 $PM_{2.5}$, SO_x, and VOC emissions decrease, while NO_x emissions increase. Overall, the benefits of reductions in $PM_{2.5}$, SO_x, and VOC emissions outweigh the disbenefits of emission increases in NO_x, resulting in an additional $4.4 billion, in present value terms, in national benefits under the SAF scenario. When broken out into the three WTT phases of SAF production, we find the feedstock and transportation phases result in overall disbenefits due to upstream emissions changes. However, the disbenefits are counteracted by the larger overall benefits of emissions reductions during the production phase. The monetized benefits from changes in upstream emissions, when combined with the benefits from changes in aircraft emissions, result in grand total public health benefits of $20 billion to $35 billion under the SAF scenario.

We note a variety of limitations and areas for future research in our analysis. First, we highlight uncertainties within our emissions reductions and air quality modeling. County-level emissions reductions are estimated by distributing state-level SAF consumption and jet fuel demands. Confidence in our estimation of county-level emissions reductions could be improved if finer scale fuel consumption and demand data was available. The FAA AEDT program used to determine the jet fuel emissions factors is limited to data from the ATL airport. Although ATL airport is the largest airport in the United States., the jet fuel emissions factor calculations would be strengthened by the inclusion of additional airport data to represent a diverse set of locations and aircraft used. The air quality modeling used, COBRA, is a single reduced form tool based on source-receptor matrix estimates. Photochemical modeling is likely to produce more robust estimates of changes in air quality due to emissions changes from mobile sources.

Additionally, COBRA's modeling of ambient $PM_{2.5}$ concentrations is limited to the county grid level. As a result, we are unable to see variations or gradients in ambient $PM_{2.5}$ concentrations at varying distances from the selected airports (i.e., the only difference present within a five-kilometer, 10-kilometer, or 15-kilometer buffer of an airport is a difference in total population exposed, unless the buffer overlaps a new county). A potential area for future research includes researching gradients in $PM_{2.5}$ pollutant levels or precursor emission levels at increasing distances from airports. A related area for future assessment would be to limit the areas assessed near a selected airport to those downwind from the airport; however, the effectiveness of this restriction would depend upon the scale of emissions and air quality modeling available (i.e., county-level estimates will not display a variation upwind vs. downwind from an airport).

When assessing upstream emissions due to SAF production, ozone-related area source BPT estimates are unavailable. Therefore, we are unable to monetize ozone-related benefits, or disbenefits, resulting from NO_x and VOC emissions during the feedstock WTT phase. Since NO_x and VOC emissions generally increased following SAF adoption, we may be underestimating the disbenefits resulting from ozone-related health effects due to increased emissions during feedstock cultivation/procurement.

Lastly, we may wish to explore a distributional evaluation of vulnerable communities. Given that most of the areas affected by the SAF scenario are metropolitan areas (i.e., areas with airports), the communities impacted are likely experiencing additional environmental justice related issues.

REFERENCES

ANL, 2022. Argonne National Laboratory, GREET Aviation Module rev2, released October 2022. Downloadable at: https://greet.es.anl.gov/greet_aviation Accessed 8/10/23.

Arter, C.A., Buonocore, J.J., Moniruzzaman, C., Yang, D., Huang, J., and Arunachalam, S. 2022. Air Quality and Health-Related Impacts of Traditional and Alternate Jet Fuels from Airport Aircraft Operations in the U.S. Environment International 158: 106958. https://doi.org/10.1016/j.envint.2021.106958.

Brunell-Yeung, E., Masek, t., Rojo, J.J., Leviy, J.I., Arunachalam, S., Miller, S.M., Barrett, S.R.H., Kuhn, S.R., and Waitz, I.A. 2014. Assessing the impact of aviation environmental policies on public health. Transport Policy 24: 21-28. https://doi.org/10.1016/j.tranpol.2014.02.015

Chung, C.S., Lane, K.J., Black-Ingersoll, F., Kolaczyk, E., Schollaert, C., Li, S., Simon, M.C., and Levy, J.I. 2023. Assessing the impact of aircraft arrival on ambient ultrafine particle number concentrations in near-airport communities in Boston, Massachusetts. Environmental Research 225: 115584. https://doi.org/10.1016/j.envres.2023.115584.

EPA. 2018. Technical Support Document (TSD): Estimating the Benefit per Ton of Reducing $PM_{2.5}$ PreCursors for 17 Sectors. https://www.epa.gov/sites/default/files/2018-02/documents/sourceapportionmentbpttsd_2018.pdf

EPA. 2021. U.S. Environmental Protection Agency, CO-Benefits Risk Assessment (COBRA) Health Impacts Screening and Mapping Tool, available at https://www.epa.gov/statelocalenergy/co-benefits-risk-assessment-cobra-health-impacts-screening-and-mapping-tool, November 2021.

EPA. 2022. Integrated Science Assessment (ISA) for Particulate Matter. https://www.epa.gov/isa/integrated-science-assessment-isa-particulate-matter

EPA. 2022. Regulatory Impact Analysis for the Proposed Reconsideration of the National Ambient Air Quality Standards for Particulate Matter. https://www.epa.gov/system/files/documents/2023-01/naaqs-pm_ria_proposed_2022-12.pdf

EPA. 2023. Technical Support Document (TSD): Estimating the Benefit per Ton of Reducing Directly-Emitted $PM_{2.5}$, $PM_{2.5}$ Precursors and Ozone Precursors from 21 Sectors. https://www.epa.gov/system/files/documents/2021-10/source-apportionment-tsd-oct-2021_0.pdf

EPA. 2023. Technical Support Document (TSD) for the 2022 PM NAAQS Reconsideration Proposal RIA - estimating PM2.5- and Ozone-Attributable Health Benefits. https://www.epa.gov/system/files/documents/2023-01/Estimating%20PM2.5-%20and%20Ozone-Attributable%20Health%20Benefits%20TSD_0.pdf

Federal Aviation Administration (FAA). 2015. Aviation Emissions, Impacts and Mitigation: A Primer. Office of Environment and Energy. https://www.faa.gov/sites/faa.gov/files/regulations_policies/policy_guidance/envir_policy/Primer_Jan2015.pdf

Federal Aviation Administration (FAA). 2019. United States 2021 Aviation Climate Action Plan. https://www.faa.gov/sites/faa.gov/files/2021-11/Aviation_Climate_Action_Plan.pdf

Federal Aviation Administration (FAA). 2023. Airport Data and Information Portal (ADIP). https://adip.faa.gov/agis/public/#/public. Accessed 5/19/2023.

Hudda, N., Simon, M.C., Zamore, W., and Durant, J.L. 2018. Aviation-Related Impacts on Ultrafine Particle Number Concentrations Outside and Inside Residences near an Airport. Environmental Science & Technology 52: 1765-1772. https://doi.org/10.1021/acs.est.7b05593.

Lawal, A.S., Russel, A.G., and Kaiser, J. 2022. Assessment of Airport-Related Emissions and Their Impact on Air Quality in Atlanta, GA, Using CMAQ and TROPOMI. Environmental Science & Technology 56: 98-108. https://doi.org/10.1021/acs.est.1c03388.

Lobo, P., Hagen, D.E., and Whitefield, P.D. 2011. Comparison of PM Emissions from a Commercial Jet Engine Burning Conventional, Biomass, and Fischer-Tropsch Fuel. Environmental Science & Technology 45, no. 24: 10744-10749. https://doi.org/10.1021/es201902e.

Pope III, C.A., Lefler, J.S., Ezzati, M., Higbee, J.D., Marshall, J.D., Kim, S-Y, Bechle, M., Gilliat, K.S., Vernon, S.E., and Robinson, A.L. 2019. Mortality risk and fine particulate air pollution in a large, representative cohort of US adults. Environmental health perspectives 127(7): 077007.

White House Office of Management and Budget’s (OMB). 2023. Circular No. A-4. Washington, DC. https://www.whitehouse.gov/wp-content/uploads/2023/11/CircularA-4.pdf

Woods & Poole Economics Inc. 2015. Complete Demographic Database. Washington, DC. http://www.woodsandpoole.com/index.php.

Wu, X., Braun, D., Schwartz, J., Kioumourtzoglou, M., and Dominici, F. 2020. Evaluating the impact of long-term exposure to fine particulate matter on mortality among the elderly. Science advances 6(29): eaba5692.

Yakovlieva, A., Boichenko, S., Lejda, K., and Vovk, O. 2019. Modification of Jet Fuels Composition with Renewable Bio-Additives. National Aviation University. https://doi.org/10.18372/37895.

Appendix A | Additional Results

This Appendix provides:

- National health impact results from SAF use for all intermediate years analyzed.
- National monetized health benefits from SAF use for all intermediate years analyzed.
- National non-fatal health impact results and monetized health benefits by health effect from SAF use.
- State level health impact and monetized benefits results from SAF use.
- Airport level health impact and monetized benefits results from SAF use for all 200 airports assessed.
- Upstream emissions monetized health benefits for all intermediate years analyzed.

Table A.1. National Health Effects Results from SAF Use for All Intermediate Years Analyzed

Benefits Estimate	Year 2025	Year 2030	Year 2035	Year 2040	Year 2045	Year 2050	Total (2025 – 2050)
Mortality-related benefits - Pope III et al. 2019 (18-99)	5.7	40.1	105.8	154.0	200.1	255.9	3,285
Mortality-related benefits - Wu et al., 2020 (65-99)	2.6	19.1	51.7	76.7	101.1	131.0	1,644

Table A.2. National Monetized Health Benefits Results from SAF Use for All Intermediate Years Analyzed (rounded to two significant figures, Billions $2023)

Benefits Estimate	Year 2025	Year 2030	Year 2035	Year 2040	Year 2045	Year 2050	Total (2025 – 2050)	Present Value (2025 – 2050)
	Undiscounted[1]							*2% Discount Rate[2]*
Avoided $PM_{2.5}$-related premature deaths using Pope III et al., 2019, plus associated morbidities	**$0.073**	**$0.53**	**$1.4**	**$2.1**	**$2.8**	**$3.7**	**$46**	**$31**
Avoided non-fatal effects	*$0.00089*	*$0.0061*	*$0.015*	*$0.021*	*$0.027*	*$0.033*	*$0.45*	*$0.30*
Avoided premature mortality	*$0.072*	*$0.52*	*$1.4*	*$2.1*	*$2.8*	*$3.7*	*$45*	*$31*
Avoided $PM_{2.5}$-related premature deaths using Wu et al., 2020, plus associated morbidities	**$0.034**	**$0.25**	**$0.7**	**$1.1**	**$1.4**	**$1.9**	**$23**	**$16**
Avoided non-fatal effects	*$0.00089*	*$0.0061*	*$0.015*	*$0.021*	*$0.027*	*$0.033*	*$0.45*	*$0.30*
Avoided premature mortality	*$0.033*	*$0.25*	*$0.69*	*$1.0*	*$1.4*	*$1.9*	*$23*	*$15*

Notes:

1. *Valuation of premature mortality within BenMAP-CE applies a 20-year cessation lag with a discount rate of two percent.*
2. *Present Value is discounted to year 2023 at a two percent discount rate, consistent with the recommendations of the White House Office of Management and Budget's Circular A-4 (2023)*

Table A.3. National Non-Fatal Health Effects Results from SAF Use (rounded to two significant figures)

Endpoint	Author	Age Range	2025	2030	2035	2040	2045	2050	Total (2025 – 2050)
Long-Term $PM_{2.5}$ Exposure									
Incidence, Asthma	Tetreault et al.	0 – 17	8.0	54	130	180	230	280	3,900
HA, Alzheimers Disease	Kioumourtzoglou et al.	65 – 99	1.2	9.3	26	40	52	68	840
HA, Parkinsons Disease	Kioumourtzoglou et al.	65 – 99	0.17	1.3	3.4	4.8	6.2	8.0	100
Incidence, Lung Cancer	Gharibvand et al.	30 – 99	0.21	1.5	4.1	6.1	7.9	10	130
Incidence, Hay Fever/ Rhinitis	Parker et al.	3 – 17	51	350	870	1,200	1,500	1,900	25,000
Short-Term $PM_{2.5}$ Exposure									
Acute Myocardial Infarction Nonfatal	Wei et al.	65 – 99	0.17	1.3	3.5	5.2	6.8	8.8	110
Asthma Symptoms, Albuterol use	Rabinovitch et al.	6 – 17	1,500	10,000	26,000	35,000	44,000	54,000	740,000
ER visits, Respiratory	Krall et al.	0 - 99	1.8	12	31	44	55	70	930
ER visits, All Cardiac Outcomes	Ostro et al.	0 – 99	0.85	6.1	16	24	31	40	500
HA, All Respiratory	Ostro et al.; Bell et al.	0 - 99	0.31	2.2	5.5	7.6	9.6	12	160
HA, All Cardiac Outcomes	Bell et al.	65 – 99	0.4	3.0	8.3	12	16	21	260
Incidence, Out of Hospital Cardiac Arrest	Ensor et al.; Silverman et al.; Rosenthal et al.	0 – 99	0.048	0.35	0.89	1.3	1.6	2.0	27
Incidence, Stroke	Kloog et al.	65 – 99	0.18	1.3	3.4	4.9	6.2	8.1	100
Minor Restricted Activity Days	Ostro and Rothschild	18 - 64	2,400	16,000	40,000	57,000	72,000	91,000	1,200,000
Work Loss Days	Ostro	18 - 64	410	2,800	6,900	9,600	12,000	15,000	200,000

Table A.4. National Monetized Non-Fatal Health Effects from SAF Use (rounded to two significant figures, Thousands $2023)

Endpoint	Author	Age Range	2025	2030	2035	2040	2045	2050	Total Undiscounted[1] (2025 – 2050)	Total Present Value[2] (2025 – 2050)
Long-Term $PM_{2.5}$ Exposure										
Incidence, Asthma	Tetreault et al.	0 – 17	$460	$3,100	$7,600	$10,000	$13,000	$16,000	$220,000	$150,000
HA, Alzheimers Disease	Kioumourtzoglou et al.	65 – 99	$18	$140	$390	$590	$790	$1,000	$13,000	$8,600
HA, Parkinsons Disease	Kioumourtzoglou et al.	65 – 99	$2.8	$21	$54	$77	$99	$130	$1,600	$1,100
Incidence, Lung Cancer	Gharibvand et al.	30 – 99	$12	$86	$230	$350	$450	$580	$7,400	$5,000
Incidence, Hay Fever/ Rhinitis	Parker et al.	3 – 17	$38	$260	$650	$880	$1,100	$1,400	$19,000	$13,000
Short-Term $PM_{2.5}$ Exposure										
Acute Myocardial Infarction Nonfatal	Wei et al.	65 – 99	$5.2	$39	$110	$160	$200	$260	$3,300	$2,200
Asthma Symptoms, Albuterol use	Rabinovitch et al.	6 – 17	$0.63	$4.3	$11	$15	$19	$23	$320	$210
ER visits, Respiratory	Krall et al.	0 - 99	$1.9	$13	$34	$47	$60	$75	$1,000	$680
ER visits, All Cardiac Outcomes	Ostro et al.	0 – 99	$1.2	$8.8	$23	$34	$44	$56	$720	$490
HA, All Respiratory	Ostro et al.; Bell et al.	0 - 99	$5.7	$41	$110	$150	$190	$250	$3,200	$2,200
HA, All Cardiac Outcomes	Bell et al.	65 – 99	$7.7	$58	$160	$230	$310	$400	$5,000	$3,400
Incidence, Out of Hospital Cardiac Arrest	Ensor et al.; Silverman et al.; Rosenthal et al.	0 – 99	$2.1	$15	$39	$55	$70	$90	$1,200	$800
Incidence, Stroke	Kloog et al.	65 – 99	$7.3	$54	$140	$200	$260	$340	$4,300	$2,900
Minor Restricted Activity Days	Ostro and Rothschild	18 - 64	$230	$1,600	$4,000	$5,600	$7,200	$9,200	$120,000	$81,000
Work Loss Days	Ostro	18 - 64	$99	$660	$1,600	$2,300	$2,900	$3,700	$49,000	$33,000

Notes:

1. *Valuation of premature mortality within BenMAP-CE applies a 20-year cessation lag with a discount rate of two percent.*
2. *Present Value is discounted to year 2023 at a two percent discount rate, consistent with the recommendations of the White House Office of Management and Budget's Circular A-4 (2023)*

Table A.5. Avoided Premature Mortality by State and Airport from SAF Use Using Pope III et al., 2019 (rounded to two significant figures)

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Alabama	**0.33**	**0.66**	**9.3**	**$110**	**$88**
Birmingham-Shuttlesworth Intl	0.015	0.025	0.38	$5.3	$3.7
Huntsville Intl-Carl T Jones Fld	0.0018	0.0042	0.055	$0.77	$0.52
Arizona	**1.6**	**4.3**	**52**	**$620**	**$490**
Phoenix Sky Harbor Intl	0.018	0.051	0.61	$8.6	$5.8
Falcon Fld	0.0022	0.0059	0.072	$1.0	$0.68
Tucson Intl	0.0017	0.0047	0.056	$0.78	$0.53
Phoenix-Mesa Gateway	0.0007	0.0018	0.022	$0.31	$0.21
Scottsdale	0.00064	0.0016	0.021	$0.29	$0.19
Prescott Rgnl - Ernest A Love Fld	0.0003	0.001	0.011	$0.15	$0.1
Yuma Mcas/Yuma Intl	0.00025	0.00069	0.0084	$0.12	$0.079
Flagstaff Pulliam	0.0000099	0.000033	0.00037	$0.0052	$0.0035
Grand Canyon Ntl Park	0.0000005	0.000001	0.000014	$0.00019	$0.00013
Arkansas	**0.19**	**0.38**	**5.3**	**$63**	**$51**
Bill And Hillary Clinton Ntl/Adams Fld	0.0057	0.011	0.16	$2.2	$1.5
Northwest Arkansas Ntl	0.00045	0.0013	0.015	$0.22	$0.14
California	**46**	**120**	**1,500**	**$17,000**	**$14,000**
San Francisco Intl	2.8	6.7	86	$1,200	$810
Los Angeles Intl	2.6	6.4	81	$1,100	$770
John Wayne/Orange County	1.4	4.1	48	$670	$450
Norman Y Mineta San Jose Intl	1.1	2.9	36	$510	$340
Metro Oakland Intl	1.2	2.7	36	$500	$340
San Diego Intl	0.89	2.6	30	$430	$280
Bob Hope	0.35	0.85	11	$150	$100
Sacramento Intl	0.24	0.61	7.6	$110	$72

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Long Beach (Daugherty Fld)	0.14	0.36	4.5	$63	$42
Van Nuys	0.077	0.18	2.3	$33	$22
San Carlos	0.069	0.17	2.2	$30	$21
Sacramento Mather	0.068	0.15	2.0	$28	$19
Fresno Yosemite Intl	0.049	0.12	1.6	$22	$15
Palm Springs Intl	0.028	0.07	0.89	$12	$8.4
Ontario Intl	0.018	0.05	0.59	$8.3	$5.5
Santa Barbara Muni	0.013	0.03	0.4	$5.5	$3.7
Redding Muni	0.0095	0.024	0.3	$4.2	$2.8
Monterey Rgnl	0.007	0.014	0.2	$2.8	$1.9
San Luis County Rgnl	0.0057	0.016	0.19	$2.6	$1.8
Meadows Fld	0.0033	0.0072	0.097	$1.4	$0.93
Visalia Muni	0.0014	0.0033	0.043	$0.61	$0.41
Colorado	**0.81**	**1.8**	**24**	**$290**	**$230**
Centennial	0.013	0.041	0.47	$6.6	$4.4
Buckley Space Force Base	0.011	0.025	0.33	$4.7	$3.2
Denver Intl	0.0068	0.015	0.2	$2.8	$1.9
City Of Colorado Springs Muni	0.006	0.015	0.19	$2.6	$1.8
Grand Junction Rgnl	0.00085	0.0018	0.025	$0.35	$0.23
Aspen-Pitkin County/Sardy Fld	0.000055	0.00011	0.0015	$0.021	$0.015
Eagle County Rgnl	0.000019	0.000036	0.00053	$0.0077	$0.0052
Connecticut	**0.97**	**2.1**	**28**	**$340**	**$270**
Bradley Intl	0.012	0.025	0.34	$4.8	$3.3
Delaware	**0.15**	**0.34**	**4.5**	**$53**	**$42**
District of Columbia	**0.28**	**0.63**	**8.3**	**$99**	**$79**
Florida	**5.7**	**16**	**190**	**$2,300**	**$1,800**
Orlando Intl	0.26	1.0	10	$150	$97

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Fort Lauderdale/Hollywood Intl	0.16	0.47	5.4	$76	$51
Tampa Intl	0.098	0.24	3.1	$43	$29
Orlando Sanford Intl	0.083	0.26	2.9	$41	$27
Daytona Beach Intl	0.068	0.14	1.9	$27	$18
Palm Beach Intl	0.057	0.16	1.9	$27	$18
Vero Beach Rgnl	0.045	0.14	1.6	$22	$15
Miami Intl	0.042	0.056	1.2	$16	$12
Sarasota/Bradenton Intl	0.034	0.092	1.1	$16	$11
Southwest Florida Intl	0.033	0.089	1.1	$15	$10
St Pete-Clearwater Intl	0.026	0.043	0.69	$9.6	$6.6
Fort Lauderdale Exec	0.017	0.048	0.57	$7.9	$5.3
Jacksonville Intl	0.017	0.037	0.5	$6.9	$4.7
Pensacola Intl	0.011	0.025	0.33	$4.6	$3.1
Naples Muni	0.0078	0.03	0.31	$4.3	$2.9
Tallahassee Intl	0.0033	0.0082	0.1	$1.4	$0.97
Eglin Afb/Destin-Ft Walton Beach	0.002	0.0048	0.062	$0.86	$0.58
Key West Intl	0.00084	0.0019	0.025	$0.35	$0.24
Northwest Florida Beaches Intl	0.00045	0.001	0.014	$0.19	$0.13
Georgia	**1.4**	**3.3**	**43**	**$510**	**$410**
Hartsfield - Jackson Atlanta Intl	0.2	0.41	5.8	$81	$55
Savannah/Hilton Head Intl	0.0076	0.015	0.21	$2.9	$2.0
Idaho	**0.076**	**0.19**	**2.4**	**$28**	**$22**
Boise Air Trml/Gowen Fld	0.0064	0.018	0.21	$3.0	$2.0
Coeur D'Alene/Pappy Boyington Fld	0.0011	0.0032	0.038	$0.53	$0.36
Illinois	**3.6**	**7.6**	**100**	**$1,200**	**$990**
Chicago O'Hare Intl	0.46	0.95	13	$180	$130
Chicago Midway Intl	0.29	0.62	8.4	$120	$80

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Chicago/Rockford Intl	0.011	0.021	0.3	$4.2	$2.8
Quad Cities Intl	0.009	0.019	0.26	$3.6	$2.5
Chicago Exec	0.007	0.014	0.2	$2.7	$1.9
Southern Illinois	0.0025	0.0046	0.069	$0.96	$0.66
Indiana	**1.4**	**2.8**	**40**	**$470**	**$380**
Indianapolis Intl	0.22	0.4	5.9	$83	$57
South Bend Intl	0.015	0.029	0.42	$5.8	$4.0
Fort Wayne Intl	0.013	0.026	0.38	$5.3	$3.6
Iowa	**0.17**	**0.32**	**4.7**	**$56**	**$45**
Des Moines Intl	0.0041	0.0078	0.11	$1.6	$1.1
The Eastern Iowa	0.003	0.0059	0.085	$1.2	$0.8
Kansas	**0.13**	**0.25**	**3.7**	**$44**	**$35**
Wichita Dwight D Eisenhower Ntl	0.0061	0.012	0.17	$2.4	$1.6
Salina Rgnl	0.0011	0.002	0.03	$0.42	$0.29
Kentucky	**0.88**	**1.7**	**25**	**$290**	**$230**
Louisville Muhammad Ali Intl	0.33	0.61	9.1	$130	$86
Cincinnati/Northern Kentucky Intl	0.11	0.21	3.0	$42	$28
Blue Grass	0.023	0.045	0.65	$9.1	$6.2
Louisiana	**1.2**	**2.4**	**35**	**$410**	**$330**
Louis Armstrong New Orleans Intl	0.59	1.1	16	$230	$150
Lafayette Rgnl/Paul Fournet Fld	0.046	0.1	1.4	$19	$13
Baton Rouge Metro, Ryan Fld	0.036	0.081	1.1	$15	$10
Abbeville Chris Crusta Meml	0.019	0.037	0.53	$7.4	$5.1
Houma-Terrebonne	0.018	0.036	0.52	$7.3	$4.9
Shreveport Rgnl	0.017	0.032	0.47	$6.5	$4.5
Maine	**0.2**	**0.44**	**6.0**	**$70**	**$56**
Auburn/Lewiston Muni	0.0021	0.0038	0.057	$0.8	$0.55

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Bangor Intl	0.0008	0.0017	0.023	$0.32	$0.22
Knox County Rgnl	0.0007	0.0015	0.021	$0.29	$0.2
Maryland	**1.1**	**2.7**	**34**	**$400**	**$320**
Baltimore/Washington Intl Thurgood Marshall	0.047	0.11	1.4	$20	$13
Massachusetts	**1.2**	**2.6**	**36**	**$420**	**$340**
General Edward Lawrence Logan Intl	0.34	0.74	9.9	$140	$94
Laurence G Hanscom Fld	0.0084	0.017	0.24	$3.3	$2.3
Cape Cod Gateway	0.0066	0.017	0.21	$3.0	$2.0
Martha'S Vineyard	0.00076	0.0023	0.027	$0.37	$0.25
Nantucket Meml	0.00079	0.0018	0.024	$0.34	$0.23
Michigan	**1.3**	**2.5**	**36**	**$430**	**$340**
Detroit Metro Wayne County	0.11	0.17	2.9	$40	$27
Gerald R Ford Intl	0.0072	0.015	0.21	$2.9	$2.0
Battle Creek Exec At Kellogg Fld	0.0018	0.0034	0.05	$0.69	$0.47
Capital Region Intl	0.0011	0.0025	0.034	$0.48	$0.32
Mackinac County	0.000028	0.000059	0.00082	$0.011	$0.0077
Minnesota	**0.67**	**1.4**	**19**	**$230**	**$180**
Minneapolis-St Paul Intl/Wold-Chamberlain	0.23	0.47	6.6	$93	$63
Mississippi	**0.35**	**0.74**	**10**	**$120**	**$96**
Jackson-Medgar Wiley Evers Intl	0.034	0.073	0.99	$14	$9.4
Missouri	**0.38**	**0.72**	**10**	**$120**	**$99**
St Louis Lambert Intl	0.072	0.15	2.1	$29	$20
Kansas City Intl	0.0065	0.015	0.2	$2.8	$1.9
Springfield-Branson Ntl	0.0022	0.0045	0.063	$0.88	$0.6
Charles B Wheeler Downtown	0.0015	0.0031	0.044	$0.62	$0.42
Montana	**0.048**	**0.11**	**1.5**	**$17**	**$14**

State Name	Avoided Premature Deaths			Monetized Results, Including Non-Fatal Health Effects (millions $2023)	
	2035	2050	Total (2025 - 2050)	Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Billings Logan Intl	0.00091	0.0023	0.029	$0.4	$0.27
Bozeman Yellowstone Intl	0.00063	0.002	0.023	$0.32	$0.21
Missoula Montana	0.00055	0.0012	0.016	$0.23	$0.15
Great Falls Intl	0.00031	0.00063	0.0088	$0.12	$0.083
Glacier Park Intl	0.00018	0.00047	0.0058	$0.081	$0.054
Nebraska	**0.084**	**0.16**	**2.3**	**$27**	**$22**
Eppley Airfield	0.0091	0.015	0.24	$3.4	$2.3
Nevada	**0.98**	**3.2**	**36**	**$420**	**$330**
Harry Reid Intl	0.022	0.076	0.82	$12	$7.7
Reno/Tahoe Intl	0.004	0.01	0.13	$1.8	$1.2
North Las Vegas	0.0019	0.0068	0.073	$1.0	$0.68
Boulder City Muni	0.00085	0.0031	0.032	$0.45	$0.3
Henderson Exec	0.00046	0.0015	0.017	$0.23	$0.15
New Hampshire	**0.17**	**0.39**	**5.2**	**$62**	**$49**
Manchester Boston Rgnl	0.0019	0.0042	0.057	$0.79	$0.54
New Jersey	**6.0**	**12**	**170**	**$2,100**	**$1,600**
Newark Liberty Intl	1.8	3.7	52	$730	$500
Teterboro	0.4	0.86	12	$160	$110
New Mexico	**0.12**	**0.31**	**3.8**	**$45**	**$36**
Albuquerque Intl Sunport	0.012	0.028	0.36	$5.1	$3.4
New York	**8.3**	**19**	**250**	**$3,000**	**$2,400**
John F Kennedy Intl	0.81	2.0	25	$360	$240
Laguardia	0.76	1.8	23	$330	$220
Buffalo Niagara Intl	0.074	0.15	2.1	$29	$20
Frederick Douglass/Greater Rochester Intl	0.033	0.071	0.98	$14	$9.3
Albany Intl	0.033	0.065	0.93	$13	$8.9
Syracuse Hancock Intl	0.024	0.048	0.69	$9.6	$6.5

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Long Island Mac Arthur	0.0095	0.02	0.28	$3.9	$2.6
North Carolina	**0.96**	**2.3**	**30**	**$360**	**$280**
Charlotte/Douglas Intl	0.14	0.34	4.3	$61	$41
Raleigh-Durham Intl	0.042	0.11	1.4	$20	$13
Piedmont Triad Intl	0.0064	0.014	0.19	$2.6	$1.8
Wilmington Intl	0.0032	0.0089	0.11	$1.5	$1.
Fayetteville Rgnl/Grannis Fld	0.0025	0.0057	0.075	$1.1	$0.71
Asheville Rgnl	0.0021	0.005	0.064	$0.9	$0.6
North Dakota	**0.018**	**0.038**	**0.52**	**$6.2**	**$4.9**
Grand Forks Intl	0.0013	0.0024	0.036	$0.5	$0.34
Hector Intl	0.00093	0.0022	0.028	$0.4	$0.27
Ohio	**2.0**	**4.0**	**57**	**$670**	**$540**
Cleveland-Hopkins Intl	0.15	0.29	4.2	$59	$40
John Glenn Columbus Intl	0.087	0.17	2.4	$34	$23
James M Cox Dayton Intl	0.022	0.045	0.63	$8.7	$5.9
Ohio State University	0.021	0.043	0.61	$8.5	$5.8
Butler County Rgnl/Hogan Fld	0.017	0.03	0.45	$6.3	$4.3
Akron-Canton Rgnl	0.014	0.029	0.41	$5.7	$3.9
Toledo Exec	0.0099	0.02	0.28	$3.9	$2.7
Rickenbacker Intl	0.0049	0.0084	0.13	$1.8	$1.2
Erie-Ottawa Intl	0.0024	0.0053	0.071	$0.99	$0.67
Oklahoma	**0.46**	**0.87**	**13**	**$150**	**$120**
Will Rogers World	0.056	0.11	1.6	$22	$15
Tulsa Intl	0.051	0.094	1.4	$19	$13
Oregon	**0.29**	**0.7**	**9.0**	**$110**	**$85**
Portland Intl	0.1	0.25	3.2	$45	$30
Rogue Valley Intl - Medford	0.0043	0.011	0.14	$1.9	$1.3

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Mahlon Sweet Fld	0.0021	0.0051	0.065	$0.9	$0.61
Roberts Fld	0.0012	0.0046	0.047	$0.66	$0.44
Pennsylvania	**3.3**	**6.9**	**96**	**$1,100**	**$900**
Philadelphia Intl	0.23	0.46	6.4	$90	$61
Allegheny County	0.037	0.071	1.0	$14	$9.8
Pittsburgh Intl	0.037	0.07	1.0	$14	$9.7
Harrisburg Intl	0.02	0.042	0.59	$8.2	$5.6
Lehigh Valley Intl	0.013	0.031	0.41	$5.7	$3.9
Rhode Island	**0.18**	**0.39**	**5.4**	**$63**	**$51**
Rhode Island Tf Green Intl	0.011	0.025	0.33	$4.6	$3.1
South Carolina	**0.38**	**1.0**	**12**	**$150**	**$120**
Myrtle Beach Intl	0.013	0.041	0.46	$6.5	$4.3
Charleston Afb/Intl	0.007	0.022	0.25	$3.5	$2.4
Greenville Spartanburg Intl	0.0052	0.013	0.16	$2.3	$1.5
Columbia Metro	0.0039	0.011	0.13	$1.8	$1.2
South Dakota	**0.027**	**0.055**	**0.78**	**$9.2**	**$7.4**
Joe Foss Fld	0.0027	0.0057	0.078	$1.1	$0.74
Rapid City Rgnl	0.00059	0.0014	0.018	$0.25	$0.17
Tennessee	**0.94**	**1.9**	**27**	**$320**	**$260**
Nashville Intl	0.12	0.24	3.4	$47	$32
Memphis Intl	0.12	0.22	3.3	$46	$31
Mc Ghee Tyson	0.022	0.053	0.68	$9.5	$6.4
Lovell Fld	0.014	0.029	0.41	$5.7	$3.9
John C Tune	0.0087	0.014	0.23	$3.2	$2.2
Texas	**8.1**	**20**	**250**	**$3,000**	**$2,400**
Dallas-Fort Worth Intl	0.46	1.1	14	$200	$130
George Bush Intcntl/Houston	0.39	0.97	12	$170	$120

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
San Antonio Intl	0.3	0.75	9.4	$130	$89
William P Hobby	0.13	0.33	4.1	$58	$39
Dallas Love Fld	0.11	0.25	3.4	$47	$32
El Paso Intl	0.087	0.27	3.0	$42	$28
Austin-Bergstrom Intl	0.047	0.11	1.4	$20	$14
Laredo Intl	0.0067	0.019	0.22	$3.2	$2.1
Ellington	0.0067	0.016	0.2	$2.9	$1.9
Lubbock Preston Smith Intl	0.0067	0.015	0.2	$2.8	$1.9
Midland Intl Air And Space Port	0.0061	0.015	0.19	$2.7	$1.8
Fort Worth Alliance	0.0034	0.0074	0.1	$1.4	$0.96
Utah	**0.43**	**1.1**	**13**	**$160**	**$130**
Salt Lake City Intl	0.087	0.22	2.7	$39	$26
Vermont	**0.084**	**0.19**	**2.6**	**$30**	**$24**
Burlington Intl	0.002	0.0053	0.065	$0.91	$0.61
Virginia	**1.3**	**3.3**	**41**	**$480**	**$380**
Ronald Reagan Washington Ntl	0.73	1.8	23	$320	$210
Washington Dulles Intl	0.073	0.25	2.8	$39	$26
Norfolk Intl	0.057	0.12	1.7	$23	$16
Richmond Intl	0.023	0.057	0.73	$10	$6.9
Charlottesville-Albemarle	0.0033	0.0072	0.099	$1.4	$0.94
Washington	**1.3**	**3.1**	**40**	**$480**	**$380**
Seattle-Tacoma Intl	0.1	0.26	3.2	$45	$31
Boeing Fld/King County Intl	0.017	0.045	0.55	$7.7	$5.1
Spokane Intl	0.0078	0.016	0.22	$3.1	$2.1
Bellingham Intl	0.0048	0.012	0.15	$2.1	$1.4
Tri-Cities	0.0027	0.0079	0.092	$1.3	$0.86
Friday Harbor	0.0021	0.0062	0.072	$1.0	$0.67

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Grant County Intl	0.00048	0.0012	0.015	$0.22	$0.15
West Virginia	**0.15**	**0.3**	**4.2**	**$50**	**$40**
Morgantown Muni-Walter L Bill Hart Fld	0.00082	0.0018	0.024	$0.33	$0.23
Wisconsin	**0.38**	**0.79**	**11**	**$130**	**$110**
General Mitchell Intl	0.017	0.031	0.47	$6.5	$4.4
Dane County Rgnl/Truax Fld	0.0037	0.008	0.11	$1.5	$1.0
Green Bay/Austin Straubel Intl	0.0021	0.0043	0.061	$0.85	$0.57
Wyoming	**0.021**	**0.047**	**0.62**	**$7.4**	**$5.9**
Jackson Hole	0.000031	0.00008	0.00098	$0.014	$0.0092

Notes:

1. *Valuation of premature mortality within BenMAP-CE applies a 20-year cessation lag with a discount rate of two percent.*
2. *Present Value is discounted to year 2023 at a two percent discount rate, consistent with the recommendations of the White House Office of Management and Budget's Circular A-4 (2023)*

Table A.6. Avoided Premature Mortality by State and Airport from SAF Use Using Wu et al., 2020 (rounded to two significant figures)

State Name	Avoided Premature Deaths			Monetized Results, Including Non-Fatal Health Effects (millions $2023)	
	2035	2050	Total (2025 - 2050)	Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Alabama	**0.15**	**0.33**	**4.5**	**$54**	**$43**
Birmingham-Shuttlesworth Intl	0.0068	0.012	0.18	$2.5	$1.7
Huntsville Intl-Carl T Jones Fld	0.00084	0.0021	0.027	$0.38	$0.26
Arizona	**0.78**	**2.2**	**26**	**$320**	**$250**
Phoenix Sky Harbor Intl	0.0084	0.025	0.29	$4.2	$2.8
Falcon Fld	0.0011	0.0032	0.038	$0.53	$0.36
Tucson Intl	0.00082	0.0024	0.028	$0.39	$0.26
Phoenix-Mesa Gateway	0.00033	0.00088	0.011	$0.15	$0.1
Scottsdale	0.00032	0.00084	0.01	$0.15	$0.099
Prescott Rgnl - Ernest A Love Fld	0.00016	0.00055	0.0059	$0.083	$0.055
Yuma Mcas/Yuma Intl	0.00012	0.00036	0.0042	$0.06	$0.04
Flagstaff Pulliam	0.0000046	0.000017	0.00018	$0.0026	$0.0017
Grand Canyon Ntl Park	0.0000001	0.0000002	0.0000029	$0.000046	$0.000032
Arkansas	**0.087**	**0.19**	**2.6**	**$31**	**$25**
Bill And Hillary Clinton Ntl/Adams Fld	0.0026	0.0051	0.073	$1.0	$0.7
Northwest Arkansas Ntl	0.0002	0.00062	0.0072	$0.1	$0.07
California	**23**	**61**	**740**	**$8,900**	**$7,000**
San Francisco Intl	1.4	3.5	44	$630	$420
Los Angeles Intl	1.3	3.3	40	$570	$390
John Wayne/Orange County	0.71	2.2	25	$350	$230
Norman Y Mineta San Jose Intl	0.55	1.5	18	$260	$180
Metro Oakland Intl	0.59	1.3	18	$250	$170
San Diego Intl	0.45	1.4	16	$220	$150
Bob Hope	0.17	0.44	5.4	$77	$52
Sacramento Intl	0.12	0.3	3.7	$53	$36
Long Beach (Daugherty Fld)	0.068	0.18	2.2	$32	$21

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Van Nuys	0.037	0.089	1.2	$16	$11
San Carlos	0.036	0.091	1.1	$16	$11
Sacramento Mather	0.033	0.077	1.0	$14	$9.6
Fresno Yosemite Intl	0.024	0.063	0.77	$11	$7.3
Palm Springs Intl	0.015	0.038	0.47	$6.6	$4.5
Ontario Intl	0.0082	0.025	0.28	$4.0	$2.7
Santa Barbara Muni	0.0066	0.015	0.2	$2.9	$1.9
Redding Muni	0.0048	0.012	0.15	$2.2	$1.5
Monterey Rgnl	0.0036	0.0076	0.11	$1.5	$1.0
San Luis County Rgnl	0.003	0.0084	0.1	$1.4	$0.94
Meadows Fld	0.0015	0.0035	0.046	$0.65	$0.44
Visalia Muni	0.00067	0.0016	0.021	$0.29	$0.2
Colorado	**0.37**	**0.89**	**11**	**$140**	**$110**
Centennial	0.0066	0.022	0.24	$3.4	$2.3
Buckley Space Force Base	0.0051	0.012	0.16	$2.3	$1.5
City Of Colorado Springs Muni	0.0029	0.0073	0.093	$1.3	$0.89
Denver Intl	0.0023	0.0056	0.072	$1.1	$0.74
Grand Junction Rgnl	0.00043	0.00091	0.013	$0.18	$0.12
Aspen-Pitkin County/Sardy Fld	0.000023	0.000047	0.00067	$0.0096	$0.0065
Eagle County Rgnl	0.0000073	0.000015	0.00021	$0.0033	$0.0022
Connecticut	**0.49**	**1.1**	**15**	**$180**	**$140**
Bradley Intl	0.0061	0.013	0.18	$2.5	$1.7
Delaware	**0.072**	**0.17**	**2.2**	**$27**	**$21**
District of Columbia	**0.12**	**0.31**	**3.8**	**$46**	**$37**
Florida	**2.8**	**8.4**	**97**	**$1,200**	**$910**
Orlando Intl	0.13	0.55	5.3	$76	$50
Fort Lauderdale/Hollywood Intl	0.079	0.25	2.8	$39	$26

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Orlando Sanford Intl	0.041	0.13	1.5	$21	$14
Tampa Intl	0.046	0.12	1.5	$21	$14
Daytona Beach Intl	0.035	0.07	0.99	$14	$9.4
Palm Beach Intl	0.029	0.084	0.99	$14	$9.3
Vero Beach Rgnl	0.024	0.075	0.86	$12	$8.0
Sarasota/Bradenton Intl	0.018	0.049	0.6	$8.4	$5.6
Miami Intl	0.021	0.029	0.59	$8.2	$5.9
Southwest Florida Intl	0.016	0.045	0.54	$7.7	$5.1
St Pete-Clearwater Intl	0.013	0.021	0.34	$4.8	$3.3
Fort Lauderdale Exec	0.0085	0.025	0.29	$4.1	$2.7
Jacksonville Intl	0.0078	0.018	0.23	$3.3	$2.2
Naples Muni	0.0042	0.016	0.17	$2.4	$1.6
Pensacola Intl	0.0053	0.012	0.16	$2.3	$1.5
Tallahassee Intl	0.0016	0.004	0.05	$0.71	$0.48
Eglin Afb/Destin-Ft Walton Beach	0.001	0.0025	0.032	$0.45	$0.3
Key West Intl	0.00037	0.00089	0.011	$0.16	$0.11
Northwest Florida Beaches Intl	0.00021	0.0005	0.0065	$0.092	$0.062
Georgia	**0.66**	**1.6**	**21**	**$250**	**$200**
Hartsfield - Jackson Atlanta Intl	0.092	0.2	2.7	$38	$26
Savannah/Hilton Head Intl	0.0034	0.0067	0.096	$1.4	$0.93
Idaho	**0.038**	**0.096**	**1.2**	**$15**	**$11**
Boise Air Trml/Gowen Fld	0.0033	0.0093	0.11	$1.6	$1.0
Coeur D'Alene/Pappy Boyington Fld	0.00059	0.0017	0.02	$0.28	$0.19
Illinois	**1.7**	**3.9**	**52**	**$620**	**$490**
Chicago O'Hare Intl	0.22	0.48	6.5	$91	$62
Chicago Midway Intl	0.14	0.31	4.1	$58	$39
Chicago/Rockford Intl	0.0052	0.011	0.15	$2.1	$1.4

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Quad Cities Intl	0.0045	0.0097	0.13	$1.9	$1.3
Chicago Exec	0.0034	0.0069	0.098	$1.4	$0.94
Southern Illinois	0.0012	0.0021	0.032	$0.45	$0.31
Indiana	**0.67**	**1.4**	**19**	**$230**	**$180**
Indianapolis Intl	0.098	0.19	2.7	$39	$26
South Bend Intl	0.0074	0.015	0.21	$2.9	$2.0
Fort Wayne Intl	0.0066	0.013	0.19	$2.7	$1.8
Iowa	**0.086**	**0.16**	**2.4**	**$29**	**$23**
Des Moines Intl	0.002	0.0039	0.056	$0.79	$0.54
The Eastern Iowa	0.0015	0.0031	0.043	$0.61	$0.41
Kansas	**0.066**	**0.13**	**1.8**	**$22**	**$18**
Wichita Dwight D Eisenhower Ntl	0.0029	0.0058	0.082	$1.2	$0.79
Salina Rgnl	0.00055	0.00099	0.015	$0.21	$0.14
Kentucky	**0.42**	**0.84**	**12**	**$140**	**$110**
Louisville Muhammad Ali Intl	0.15	0.3	4.3	$61	$42
Cincinnati/Northern Kentucky Intl	0.051	0.1	1.5	$21	$14
Blue Grass	0.011	0.022	0.31	$4.4	$3.0
Louisiana	**0.56**	**1.2**	**16**	**$200**	**$160**
Louis Armstrong New Orleans Intl	0.27	0.54	7.7	$110	$74
Lafayette Rgnl/Paul Fournet Fld	0.022	0.05	0.66	$9.4	$6.3
Baton Rouge Metro, Ryan Fld	0.017	0.039	0.51	$7.3	$4.9
Abbeville Chris Crusta Meml	0.0088	0.018	0.25	$3.6	$2.4
Houma-Terrebonne	0.0085	0.017	0.24	$3.4	$2.3
Shreveport Rgnl	0.0078	0.016	0.22	$3.1	$2.1
Maine	**0.1**	**0.23**	**3.1**	**$37**	**$29**
Auburn/Lewiston Muni	0.001	0.0019	0.029	$0.41	$0.28
Bangor Intl	0.0004	0.00086	0.012	$0.17	$0.11

State Name	Avoided Premature Deaths 2035	Avoided Premature Deaths 2050	Avoided Premature Deaths Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Present Value[2] (2025 - 2050)
Knox County Rgnl	0.00037	0.00082	0.011	$0.15	$0.1
Maryland	**0.52**	**1.4**	**17**	**$210**	**$160**
Baltimore/Washington Intl Thurgood Marshall	0.022	0.053	0.69	$9.8	$6.6
Massachusetts	**0.61**	**1.3**	**18**	**$220**	**$170**
General Edward Lawrence Logan Intl	0.16	0.37	4.8	$68	$46
Laurence G Hanscom Fld	0.0043	0.0087	0.12	$1.7	$1.2
Cape Cod Gateway	0.0035	0.009	0.11	$1.6	$1.1
Martha'S Vineyard	0.00041	0.0012	0.014	$0.2	$0.13
Nantucket Meml	0.00039	0.00096	0.012	$0.18	$0.12
Michigan	**0.62**	**1.3**	**18**	**$210**	**$170**
Detroit Metro Wayne County	0.053	0.082	1.3	$19	$13
Gerald R Ford Intl	0.0036	0.0075	0.1	$1.5	$1.
Battle Creek Exec At Kellogg Fld	0.00086	0.0017	0.024	$0.34	$0.23
Capital Region Intl	0.00058	0.0013	0.017	$0.25	$0.17
Mackinac County	0.000015	0.000032	0.00043	$0.0061	$0.0041
Minnesota	**0.34**	**0.72**	**9.9**	**$120**	**$95**
Minneapolis-St Paul Intl/Wold-Chamberlain	0.12	0.24	3.4	$48	$32
Mississippi	**0.16**	**0.36**	**4.8**	**$58**	**$46**
Jackson-Medgar Wiley Evers Intl	0.015	0.036	0.47	$6.7	$4.5
Missouri	**0.18**	**0.36**	**5.1**	**$62**	**$49**
St Louis Lambert Intl	0.036	0.078	1.1	$15	$10
Kansas City Intl	0.0032	0.0074	0.099	$1.4	$0.95
Springfield-Branson Ntl	0.001	0.0022	0.031	$0.43	$0.29
Charles B Wheeler Downtown	0.00074	0.0016	0.022	$0.31	$0.21
Montana	**0.024**	**0.058**	**0.75**	**$9.0**	**$7.1**
Billings Logan Intl	0.00046	0.0012	0.015	$0.21	$0.14
Bozeman Yellowstone Intl	0.00032	0.0011	0.012	$0.17	$0.11

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Missoula Montana	0.00028	0.00063	0.0083	$0.12	$0.079
Great Falls Intl	0.00015	0.00032	0.0045	$0.062	$0.042
Glacier Park Intl	0.000093	0.00025	0.003	$0.042	$0.029
Nebraska	**0.041**	**0.08**	**1.2**	**$14**	**$11**
Eppley Airfield	0.0044	0.0076	0.12	$1.7	$1.1
Nevada	**0.48**	**1.7**	**18**	**$220**	**$170**
Harry Reid Intl	0.011	0.04	0.42	$5.9	$3.9
Reno/Tahoe Intl	0.002	0.0051	0.063	$0.89	$0.6
North Las Vegas	0.00094	0.0036	0.037	$0.53	$0.35
Boulder City Muni	0.00044	0.0016	0.017	$0.24	$0.16
Henderson Exec	0.00022	0.00078	0.0084	$0.12	$0.079
New Hampshire	**0.089**	**0.2**	**2.7**	**$32**	**$26**
Manchester Boston Rgnl	0.00096	0.0022	0.029	$0.41	$0.28
New Jersey	**2.9**	**6.3**	**86**	**$1,000**	**$820**
Newark Liberty Intl	0.82	1.8	24	$350	$240
Teterboro	0.2	0.45	6.0	$84	$57
New Mexico	**0.057**	**0.16**	**1.9**	**$23**	**$18**
Albuquerque Intl Sunport	0.0057	0.014	0.18	$2.5	$1.7
New York	**4.0**	**9.6**	**120**	**$1,500**	**$1,200**
John F Kennedy Intl	0.4	1.0	13	$180	$120
Laguardia	0.37	0.91	11	$160	$110
Buffalo Niagara Intl	0.038	0.078	1.1	$15	$10
Frederick Douglass/Greater Rochester Intl	0.017	0.037	0.51	$7.1	$4.8
Albany Intl	0.017	0.033	0.47	$6.7	$4.5
Syracuse Hancock Intl	0.012	0.025	0.36	$5.0	$3.4
Long Island Mac Arthur	0.0047	0.01	0.14	$2.0	$1.3
North Carolina	**0.47**	**1.2**	**15**	**$180**	**$140**

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Charlotte/Douglas Intl	0.065	0.17	2.1	$30	$20
Raleigh-Durham Intl	0.021	0.06	0.72	$10	$6.8
Piedmont Triad Intl	0.0031	0.0068	0.093	$1.3	$0.89
Wilmington Intl	0.0016	0.0046	0.054	$0.77	$0.51
Fayetteville Rgnl/Grannis Fld	0.0011	0.0028	0.035	$0.5	$0.34
Asheville Rgnl	0.001	0.0026	0.033	$0.46	$0.31
North Dakota	**0.0087**	**0.02**	**0.26**	**$3.1**	**$2.5**
Grand Forks Intl	0.00065	0.0011	0.017	$0.25	$0.17
Hector Intl	0.00045	0.0011	0.014	$0.2	$0.13
Ohio	**0.98**	**2.1**	**28**	**$340**	**$270**
Cleveland-Hopkins Intl	0.075	0.15	2.1	$30	$20
John Glenn Columbus Intl	0.04	0.081	1.1	$16	$11
James M Cox Dayton Intl	0.01	0.023	0.31	$4.3	$2.9
Ohio State University	0.0099	0.021	0.29	$4.1	$2.8
Butler County Rgnl/Hogan Fld	0.0079	0.014	0.22	$3.1	$2.1
Akron-Canton Rgnl	0.0072	0.015	0.21	$2.9	$2.0
Toledo Exec	0.0049	0.01	0.14	$2.0	$1.3
Rickenbacker Intl	0.0022	0.004	0.06	$0.85	$0.58
Erie-Ottawa Intl	0.0012	0.0028	0.037	$0.52	$0.35
Oklahoma	**0.21**	**0.42**	**6.0**	**$72**	**$58**
Will Rogers World	0.025	0.053	0.73	$10	$7.1
Tulsa Intl	0.023	0.044	0.65	$9.2	$6.3
Oregon	**0.14**	**0.36**	**4.5**	**$54**	**$43**
Portland Intl	0.05	0.13	1.6	$22	$15
Rogue Valley Intl - Medford	0.0022	0.0061	0.074	$1.0	$0.69
Mahlon Sweet Fld	0.0011	0.0027	0.033	$0.47	$0.32
Roberts Fld	0.00063	0.0025	0.026	$0.36	$0.24

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Pennsylvania	**1.6**	**3.5**	**48**	**$570**	**$460**
Philadelphia Intl	0.1	0.22	3.0	$43	$29
Allegheny County	0.019	0.037	0.53	$7.4	$5.1
Pittsburgh Intl	0.018	0.036	0.52	$7.3	$5.0
Harrisburg Intl	0.01	0.022	0.3	$4.2	$2.8
Lehigh Valley Intl	0.0069	0.016	0.21	$3.0	$2.0
Rhode Island	**0.092**	**0.21**	**2.8**	**$33**	**$26**
Rhode Island Tf Green Intl	0.0057	0.013	0.17	$2.4	$1.6
South Carolina	**0.19**	**0.52**	**6.3**	**$75**	**$59**
Myrtle Beach Intl	0.0065	0.022	0.24	$3.4	$2.2
Charleston Afb/Intl	0.0034	0.012	0.13	$1.8	$1.2
Greenville Spartanburg Intl	0.0026	0.0066	0.083	$1.2	$0.78
Columbia Metro	0.0019	0.0056	0.066	$0.93	$0.62
South Dakota	**0.014**	**0.028**	**0.39**	**$4.7**	**$3.8**
Joe Foss Fld	0.0013	0.0028	0.038	$0.54	$0.37
Rapid City Rgnl	0.00029	0.00072	0.0091	$0.13	$0.087
Tennessee	**0.44**	**0.92**	**13**	**$150**	**$120**
Memphis Intl	0.054	0.1	1.5	$21	$15
Nashville Intl	0.05	0.11	1.5	$21	$14
Mc Ghee Tyson	0.011	0.027	0.34	$4.8	$3.3
Lovell Fld	0.0069	0.015	0.2	$2.8	$1.9
John C Tune	0.004	0.0066	0.1	$1.5	$1.0
Texas	**3.8**	**10.0**	**120**	**$1,500**	**$1,200**
Dallas-Fort Worth Intl	0.22	0.52	6.7	$96	$65
George Bush Intcntl/Houston	0.17	0.45	5.5	$80	$53
San Antonio Intl	0.14	0.37	4.6	$65	$44
William P Hobby	0.06	0.16	2.0	$28	$19

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Dallas Love Fld	0.052	0.12	1.6	$23	$15
El Paso Intl	0.043	0.14	1.5	$22	$15
Austin-Bergstrom Intl	0.022	0.053	0.68	$9.8	$6.6
Laredo Intl	0.003	0.0091	0.1	$1.5	$1.0
Ellington	0.003	0.0077	0.096	$1.4	$0.93
Lubbock Preston Smith Intl	0.0032	0.0074	0.096	$1.4	$0.92
Midland Intl Air And Space Port	0.0029	0.0074	0.092	$1.3	$0.88
Fort Worth Alliance	0.0015	0.0035	0.045	$0.66	$0.44
Utah	**0.21**	**0.54**	**6.6**	**$80**	**$64**
Salt Lake City Intl	0.042	0.11	1.4	$19	$13
Vermont	**0.044**	**0.1**	**1.3**	**$16**	**$13**
Burlington Intl	0.001	0.0028	0.034	$0.48	$0.32
Virginia	**0.62**	**1.7**	**21**	**$250**	**$200**
Ronald Reagan Washington Ntl	0.35	0.91	11	$160	$110
Washington Dulles Intl	0.036	0.13	1.4	$20	$14
Norfolk Intl	0.027	0.059	0.79	$11	$7.5
Richmond Intl	0.011	0.029	0.37	$5.2	$3.5
Charlottesville-Albemarle	0.0017	0.0038	0.051	$0.72	$0.49
Washington	**0.64**	**1.6**	**20**	**$240**	**$190**
Seattle-Tacoma Intl	0.049	0.13	1.6	$23	$15
Boeing Fld/King County Intl	0.0083	0.024	0.28	$4.0	$2.6
Spokane Intl	0.0039	0.008	0.11	$1.6	$1.1
Bellingham Intl	0.0024	0.0062	0.078	$1.1	$0.74
Tri-Cities	0.0014	0.0041	0.048	$0.68	$0.45
Friday Harbor	0.0011	0.0034	0.039	$0.54	$0.36
Grant County Intl	0.00024	0.00064	0.0078	$0.11	$0.074
West Virginia	**0.073**	**0.15**	**2.1**	**$25**	**$20**

State Name	Avoided Premature Deaths 2035	2050	Total (2025 - 2050)	Monetized Results, Including Non-Fatal Health Effects (millions $2023) Total Undiscounted[1] (2025 - 2050)	Total Present Value[2] (2025 - 2050)
Morgantown Muni-Walter L Bill Hart Fld	0.00039	0.00086	0.011	$0.16	$0.11
Wisconsin	**0.19**	**0.4**	**5.6**	**$67**	**$54**
General Mitchell Intl	0.0082	0.015	0.22	$3.2	$2.2
Dane County Rgnl/Truax Fld	0.0019	0.0041	0.056	$0.79	$0.53
Green Bay/Austin Straubel Intl	0.001	0.0022	0.031	$0.44	$0.3
Wyoming	**0.01**	**0.024**	**0.31**	**$3.7**	**$2.9**
Jackson Hole	0.000015	0.000041	0.00049	$0.0069	$0.0046

Notes:

1. *Valuation of premature mortality within BenMAP-CE applies a 20-year cessation lag with a discount rate of two percent.*
2. *Present Value is discounted to year 2023 at a two percent discount rate, consistent with the recommendations of the White House Office of Management and Budget's Circular A-4 (2023)*

Table A.7. Monetized Benefits Results of SAF Production for All Intermediate Years

		Pollutant				Total	Present Value
Year	Conversion Process	$PM_{2.5}$	SO_x	NO_x[1]	VOC[2]	*Undiscounted*[3]	*2% Discount Rate*[4]
2025	Feedstock	-$24,835,495	-$14,711,193	-$12,694,382	N/A	-$52,241,070	-$49,227,927
	Refinement	-$1,464,801	-$1,047,663	-$37,899,346	$10,965,348	-$29,446,463	-$27,748,060
	Transportation	-$495,645	$457,400	-$26,801,568	-$1,961,211	-$28,801,023	-$27,139,848
	Total	**-$26,795,941**	**-$15,301,456**	**-$77,395,296**	**$9,004,137**	**-$110,488,556**	**-$104,115,834**
2030	Feedstock	-$40,114,417	-$21,738,108	-$21,216,123	N/A	-$83,068,648	-$70,898,291
	Refinement	$59,278,351	$13,897,011	$54,066,408	$80,111,752	$207,353,522	$176,974,234
	Transportation	-$855,348	$667,244	-$45,624,680	-$3,383,791	-$49,196,575	-$41,988,803
	Total	**$18,308,585**	**-$7,173,853**	**-$12,774,395**	**$76,727,962**	**$75,088,299**	**$64,087,140**
2035	Feedstock	-$43,100,197	-$22,327,458	-$23,157,269	N/A	-$88,584,924	-$68,479,028
	Refinement	$171,086,330	$41,974,870	$252,920,880	$196,916,169	$662,898,249	$512,441,907
	Transportation	-$946,861	$680,535	-$50,207,432	-$3,745,473	-$54,219,232	-$41,913,230
	Total	**$127,039,272**	**$20,327,947**	**$179,556,178**	**$193,170,695**	**$520,094,093**	**$402,049,650**
2040	Feedstock	-$79,712,577	-$22,776,978	-$49,345,091	N/A	-$151,834,646	-$106,308,451
	Refinement	$238,468,415	$58,895,858	$372,742,217	$267,316,517	$937,423,007	$656,345,507
	Transportation	-$2,252,486	$603,863	-$114,221,708	-$8,904,072	-$124,774,403	-$87,361,968
	Total	**$156,503,352**	**$36,722,743**	**$209,175,418**	**$258,412,445**	**$660,813,958**	**$462,675,088**
2045	Feedstock	-$253,640,830	-$26,523,873	-$173,184,070	N/A	-$453,348,772	-$287,493,807
	Refinement	$295,037,708	$72,961,665	$466,074,025	$328,990,722	$1,163,064,120	$737,563,994
	Transportation	-$8,411,272	$296,610	-$416,464,282	-$33,238,115	-$457,817,059	-$290,327,397
	Total	**$32,985,606**	**$46,734,402**	**-$123,574,326**	**$295,752,607**	**$251,898,289**	**$159,742,791**
2050	Feedstock	-$522,695,608	-$25,686,747	-$359,380,460	N/A	-$907,762,815	-$521,395,861

Year	Conversion Process	Pollutant PM2.5	SOx	NOx[1]	VOC[2]	Total Undiscounted[3]	Present Value 2% Discount Rate[4]
	Refinement	$369,682,971	$91,795,223	$603,413,050	$405,350,278	$1,470,241,523	$844,469,317
	Transportation	-$18,513,181	-$851,908	-$883,083,280	-$70,489,274	-$972,937,643	-$558,830,624
	Total	**-$171,525,817**	**$65,256,568**	**-$639,050,690**	**$334,861,004**	**-$410,458,936**	**-$235,757,168**
Total (2025-2050)	Feedstock	-$3,725,433,415	-$588,025,905	-$2,450,737,291	N/A	-$6,764,196,612	-$4,418,398,412
	Refinement	$4,924,008,534	$1,210,889,700	$7,425,558,762	$5,615,622,673	$19,176,079,668	$12,945,687,739
	Transportation	-$119,356,314	$10,057,736	-$5,862,245,056	-$463,708,707	-$6,435,252,341	-$4,110,963,933
	Total	**$1,079,218,805**	**$632,921,531**	**-$887,423,586**	**$5,151,913,966**	**$5,976,630,716**	**$4,416,325,395**

Notes:

1. *NO_x is a precursor emission for both ambient $PM_{2.5}$ and ozone. Therefore, the NO_x benefits are calculated using the sum of both precursor BPT estimates.*
2. *The 2018 EPA BPT TSD does not estimate ozone-related benefits. Therefore, BPT values for ozone-related benefits from NO_x and VOC emissions during feedstock phase is not assessed*
3. *Valuation of premature mortality within the BPT utilized applies a 20-year cessation lag with a discount rate of two percent.*
4. *Present Value is discounted to year 2023 at a two percent discount rate, consistent with the recommendations of the White House Office of Management and Budget's Circular A-4 (2023).*