DFW Central Terminal Area Expansion

Draft GHG and Climate Technical Report

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Acronyms and Abbreviations

ACA	Airport Carbon Accreditation
ACI	Airports Council International
AEDT	Aviation Environmental Design Tool
APU	Auxiliary Power Unit
BCSD	Bias-Correction Spatial Disaggregation
BTU	British Thermal Unit
CAP	Criteria Air Pollutant
CDD	Cooling Degree Days
CECAP	Comprehensive Environmental and Climate Action Plan
CH_4	Methane
CHW	Chilled Water
CO_2	Carbon Dioxide
CO_{2e}	Carbon Dioxide Equivalents
CTA	Central Terminal Area
CUP	Central Utility Plant
DFW	Dallas Fort Worth International Airport
eCUP	Electric Central Utility Plant
EPA	Environmental Protection Agency
FAA	Federal Aviation Administration
FY	Fiscal Year
GBS	Green Building Standard
GDDP	Global Daily Downscaled Projections
GHG	Greenhouse Gases
GSE	Ground Support Equipment
Gt	Gigatonnes (equivalent to thousand million metric tons)
GWP	Global Warming Potential
HAP	Hazardous Air Pollutants
HDD	Heating Degree Days
HHW	Heating Hot Water
IPCC	Intergovernmental Panel on Climate Change
LED	Light Emitting Diode
MMT	Million Metric Tons
N_2O	Nitrous Oxide

NEPA	National Environmental Policy Act
NEX	NASA Earth Exchange
SAF	Sustainable Aviation Fuel
SSP	Shared Socioeconomic Pathways
SMP	Sustainability Management Plan
tpy	Tons Per Year
UNEP	United Nations Environmental Programme

1. Introduction

The Dallas Fort Worth International Airport (DFW, the Airport) is located in Dallas and Tarrant counties, between the cities of Dallas and Fort Worth in Texas. This technical report has been prepared to support the environmental assessment (EA) being prepared under the National Environmental Policy Act (NEPA) and to discuss the potential environmental impacts associated with the proposed DFW Central Terminal Area (CTA) Expansion Project (the “Project” or the "Proposed Action"). In conformance with NEPA, and the President’s Council on Environmental Quality (CEQ) regulations to implement NEPA (40 Code of Federal Regulations [CFR] §1500 to 1508), this analysis identifies and assesses the affected environment and environmental impacts of the Proposed Action’s emission of greenhouse gases (GHGs).

DFW is proposing to construct the Project to increase total passenger gates, rehabilitate, reconstruct, and modernize aging infrastructure, and provide enhanced connectivity between existing and new terminal facilities. The Proposed Action includes the construction of a Pier at Terminal A, with a net five new gates, a Pier at Terminal C with a net four new gates, a new Terminal F, located south of Terminal D, with up to 22 new gates, baggage and passenger processing improvements at Terminal E in support of Terminal F, a service corridor connecting Terminals E and F, a full renovation of Terminal C, as well as associated airside ramp and apron improvements, including supporting utility, fuel, and drainage infrastructure. Overall, the proposed CTA Expansion Project would provide up to 31 new passenger gates at Terminals A, C, and F. The Proposed Action would also rehabilitate and modernize aging infrastructure within Terminal C. Furthermore, the Project would include the rehabilitation and reconstruction of the Terminal C parking garages and roadways; as well as the requisite modifications to the Skylink system and the construction of an automated people mover (APM) (aka Skylink) station to connect Terminals E and F.

Emissions inventories for GHGs were developed for the following scenarios. Detailed information on Project sources and methodology is provided under separate cover (Ramboll, 2023).

- Existing Conditions – 2022
- Future No Action (Buildout Year) – 2026
- Future No Action (5 years after Buildout Year) – 2031
- Future No Action (10 years after Buildout Year) – 2036
- Future Action Alternative (Buildout Year) – 2026
- Future Action Alternative (5 years after Buildout Year) – 2031
- Future Action Alternative (10 Years After Buildout Year) – 2036

Section 2 of this report provides information for the affected environment section of the GHG and climate change analysis chapter of the EA and associated supplementary information. Section 3 presents information for the environmental consequences section of the EA. Section 4 provides miscellaneous supplemental information supporting the environmental consequences discussion.

2. Affected Environment

The Intergovernmental Panel on Climate Change (IPCC) describes climate change as "a change in the state of the climate that can be identified (for example, by using statistical tests) by changes in the mean and/or the variability of its properties, and persists for an extended period, typically decades or longer. Climate change may be due to natural internal processes or external forcings such as modulations of the solar cycles, volcanic eruptions, and persistent anthropogenic changes in the composition of the atmosphere or in land use" (IPCC 2013, 2021).

Current ongoing global climate change is caused, in part, by the atmospheric accumulation of GHGs which may persist for decades or even centuries. Although largely invisible to the short wavelength incoming solar radiation that heats the earth’s surface, GHGs absorb a portion of the outgoing long wavelength infrared heat radiated back from the surface, preventing it from escaping out into space. As a result, the accumulation of GHGs since the start of the Industrial Revolution has increased the global mean temperature and begun to alter the earth’s climate in complex ways.

This section analyzes the three main GHGs (carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O)) associated with the aircraft and traffic operations at DFW. In addition, GHG emissions are also summarized in terms of carbon dioxide equivalents (CO_2e) using the global warming potential (GWP) of each GHG from the Sixth Assessment Report (AR6) of the IPCC (2021).[1]

Because climate change is a global issue, the analysis area for GHGs cannot be restricted to one region. Thus, the GHG/climate affected environment discussion is focused on DFW, state, and national scales.

2.1 Regulatory Framework

The IPCC stated in its 2021 assessment that human activities have unequivocally contributed to warming the atmosphere, oceans, and land, primarily due to increased greenhouse gas (GHG) concentrations traced back to the mid-18th century. These heightened GHG levels have driven extensive changes in the Earth's climate systems, resulting in notably warmer global surface temperatures and a rise in global average precipitation levels. Research has also demonstrated a direct association between GHG emissions and fuel combustion, making fuel-dependent sources at airports contributors to GHG emissions.

There are presently no ambient air standards established for GHGs, nor are there specific significance thresholds for GHG emissions within aviation, as indicated by the Federal Aviation Administration (FAA) in 2020. The FAA's 1050.1F Desk Reference (2020) outlines the general statutes and regulations concerning climate matters. Additionally, President Biden's Executive Orders from January 2021 prioritize climate action, emphasizing GHG emission reductions. One of these orders, Executive Order 13990, "Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis," directs federal agencies to address the climate crisis and underscores the importance of considering GHG emissions in decision-making. It also establishes the Interagency Working Group on the Social Cost of Greenhouse Gas Emissions.

Another significant directive, Executive Order 14008, "Tackling the Climate Crisis at Home and Abroad," reaffirms the United States' commitment to the Paris Agreement and aims to achieve net-zero emissions by 2050. This order establishes a National Climate Task Force and calls for various actions, including increasing

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[1] https://www.ipcc.ch/assessment-report/ar6/

renewable energy production on public lands and waters, assessing the climate impacts of oil and gas development on public lands, creating a civilian climate corps, and working toward the conservation of 30 percent of the nation's lands and waters by 2030.

To support these executive orders, the Council on Environmental Quality (CEQ) issued updated interim guidance in 2023[2] for the consideration of GHG emissions and climate change in National Environmental Policy Act (NEPA) reviews. This guidance builds upon prior recommendations and promotes a science-based approach.

Moreover, the United States has set a target, aligned with Executive Order 14008, to reduce net GHG emissions by 50 to 52 percent below 2005 levels by 2030, as part of its commitment under the Paris Agreement. The US has made considerable progress, having likely exceeded the 2020 target of a 17 percent reduction and remains on track to meet the 2025 goal of 26 to 28 percent emissions reductions below 2005 levels.

Emissions thresholds for GHGs from aviation have not been established in the FAA 1050.1F Desk Reference or the 2023 CEQ interim guidance.

2.2 Current Climate Conditions and Trends

The Earth's climate has undergone significant changes since the onset of the Industrial Revolution, resulting in a range of effects on the global environment. These effects can be seen in the reduction in polar sea ice and winter mountain snowpack, rising sea levels, increased nighttime minimum temperatures, altered rainfall patterns, and shifts in extreme weather events. These alterations have had far-reaching consequences on both natural and human systems, indicating their vulnerability to climate shifts (IPCC 2013, 2021).

The IPCC's report in 2021 attributes the rise in greenhouse gas (GHG) concentrations since the mid-18th century to human activities, particularly the burning of fossil fuels. It concluded that human activities such as the burning of fossil fuels have caused GHG concentrations to increase since the mid-18th century and that "it is unequivocal that human influence has warmed the atmosphere, ocean and land." This influence has led to an estimated 1.07°C (1.93°F) increase in global surface temperatures between 1850-1900 and 2010-2019, and it is "very likely" that well-mixed GHGs were the main driver of this warming since 1979. Atmospheric CO_2 concentrations were higher in 2019 than any time in at least the last 2 million years. Additionally, evidence of the observed change and the human influence in extreme events such as heat waves, heavy precipitation, and droughts has strengthened since the IPCC Fifth Assessment Report (IPCC 2014). For example, it is "virtually certain" that hot extremes have increased in frequency and intensity across most regions since the 1950s and cold extremes have become less extreme and less severe, and there is "high confidence" that human-induced climate change is the main driver of these changes (IPCC 2021).

In the United States, there has been a notable increase in average annual temperatures, with a 1.8°F rise since the early 20th century and a 1.2°F increase in recent decades. Western regions of the country have experienced the most pronounced warming, while the southeastern United States has seen the least change. Precipitation patterns have shifted as well, with increases in the north and east and decreases in the south

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[2] NEPA Interim Guidance on Consideration of Greenhouse Gas Emissions and Climate Change. Council on Environmental Quality. 86 FR 1196 (Jan. 9, 2023)

and west. Furthermore, heavy precipitation events have become more frequent and intense across most of the country since the 20th century (US Global Change Research Program 2018).

State-specific climate summaries are regularly published by the National Oceanic and Atmospheric Administration (NOAA). According to Texas' 2022 state climate summary (National Oceanic and Atmospheric Administration 2022):

- Temperatures have risen almost 1.5°F since the beginning of the 20th century, with more unprecedented warming projected this century.
- An increase in temperature can decrease soil moisture and exacerbate the intensity of naturally occurring droughts in the region. Dry spells are also projected to increase.
- Extreme events, such as extreme heat events, precipitation events, and hurricanes, are projected to increase in frequency and intensity.

Climate change is a cumulative effect of GHG emissions across the world. The United Nations Environmental Programme (UNEP) estimated the 2021 global net GHG emissions to be 52.8 gigatonnes (Gt) of CO_2e (UNEP 2022). According to EPA (2023a), the total net GHG emissions in 2021 were 5,586 million metric tons (MMT) of CO_2e in the U.S. with 836.2 MMT in the state of Texas. GHG emissions due to aviation transportation (including commercial aircraft and other aircraft) in the U.S. was 155.5 MMT of CO_2e in year 2021 (EPA 2023a) representing 2.8% of total U.S. emissions from all sources. GHG emissions from fossil fuel combustion for energy contributed the majority of GHG emissions both in Texas and in the nation.

2.3 Sustainability and Climate Related Measures Undertaken by DFW Airport

DFW's commitment to climate action aligns with the US national goal to be net zero by 2050 as outlined in the Long-Term Strategy of the United States: Pathways to Net-Zero Greenhouse Gas Emissions by 2050. The airport's 2022 Sustainability Management Plan (SMP) builds off DFW's long standing commitment to sustainability and the progress the airport has made since the 2014 SMP. The plan introduces DFW's overarching approach to sustainability across airport operations, a commitment to protecting the surrounding natural environment, and the ongoing effort to be an asset to local communities, as an employer and community member. This plan presents six 'North Star' goals that the airport is working to achieve over the next two decades:

- Climate Action: Net zero GHG emissions by 2030
- Energy Performance: 100% clean, resilient energy by 2030
- Water and Biodiversity: Water and nature positive by 2040
- Circular Economy: Zero waste by 2040
- Equity: Culture of diversity and inclusivity
- Health, Safety and Wellness: Enhanced employee and customer wellness

DFW's Sustainability Management Plan establishes a high standard of performance across these sustainability domains, and the airport tracks and reports annually on progress.

2.3.1 Climate Action and Energy

By 2030, DFW intends for airport operations within DFW's direct control to be net-zero GHG emissions. DFW's decarbonization strategy is built on three core areas: a continued transition to renewable energy sources, optimization of facilities and fleet for improved efficiency, and eventually, the use of GHG emissions removal technology. The airport is investing in cost effective, resilient on-site clean energy production and storage solutions to safeguard against disruptions or extreme events.

To meet the goal of net zero emissions by 2030, DFW has taken a number of actions, and developed a net zero roadmap detailing a set of initiatives to be implemented over the next seven years. To date, as of FY 2021, DFW has reduced absolute emissions within its control compared to 2010 levels by 80%.

Airport Carbon Accreditation (ACA): DFW is the first airport to achieve the 4+ level in ACI's global Airport Carbon Accreditation program, demonstrating an ambitious approach to reducing climate impacts and emissions. ACA is the only institutionally endorsed emissions management certification standard for airports and accredited airports, including DFW, have their carbon footprints independently verified.

Energy Consumption and Energy Sources: DFW is moving toward a goal of 100% clean energy. In 2021, DFW consumed 1.58 billion megajoules of energy of which 68% was renewable. Approximately 58% of DFW's total energy consumption was renewable electricity, and 10% was renewable natural gas. The remaining 32% was a mixture of natural gas, propane, compressed natural gas, gas, and diesel.

Electric Central Utility Plant: The largest component of DFW's GHG emissions is facility heating. These emissions come primarily from the use of natural gas boilers in the airport's Central Utility Plant (CUP) used to heat 6.5 million square feet of terminal space. DFW is constructing an Electric Central Utility Plant (eCUP) that will transition terminal heating from conventional natural gas boilers to electric heat pump chillers, which is estimated to reduce heating-related emissions by an estimated 86%. Further, new chiller units will utilize lower global warming potential refrigerants that reduce the impact of refrigerant losses. The eCUP will also provide operational flexibility and resilience, reduce water use, and yield operations and maintenance cost savings

Fleet Electrification: DFW implemented fleet electrification project to reduce its footprint and improve local air quality. This began in 2021 with two electric buses and two sedans and lays the groundwork for DFW's replacement of gas-powered vehicles with electric vehicles by 2030 in support of the net zero goal.

Renewable Natural Gas: DFW purchases renewable natural gas for its fleet of more than 150 buses. Renewable natural gas is fuel generated through the processing of organic waste material, and as such is renewable, and a cleaner source than fossil fuel generated natural gas. Since 2017, the airport has steadily increased the use of renewable natural gas to fuel this fleet. In 2021, 79% of the natural gas used in DFW buses was renewable.

Energy Efficiency: DFW is continually undertaking sustainable design approaches to reduce energy consumption for its buildings and operations. In upgrading the building envelope of the terminals to improve insulation and reduce heat losses or unwanted heat gains, one strategy DFW has pursued is the installation of dynamic glass. Dynamic glass uses an electrochromic coating to intelligently adjust the tint of the glass in response to outdoor climatic conditions. On a hot or sunny day, the windows become tinted to reduce glare and solar gains. Other strategies such as LED lighting, occupancy sensors, retrocommissioning are being implemented on an ongoing basis to reduce demand, ensure the buildings are operating optimally, and reduce energy wastage.

Scope 3 Indirect Emissions: While DFW's net zero roadmap accounts for emissions generated directly by airport-controlled activities (scopes 1 and 2), DFW strives to enable its stakeholders to achieve emissions reductions that are a part of the airport's scope 3 indirect emissions. A major source of scope 3 emissions is jet fuel. In 2021 DFW tested Sustainable Aviation Fuel (SAF) generated by used cooking oil, proving the viability of SAF while showcasing the potential to close the loop at DFW by providing raw material for the production of renewable fuels.

Resilient Energy Infrastructure: To increase energy resiliency, DFW is investing in on-site energy production and storage infrastructure. Batteries will store excess energy which can be drawn upon in the event of service outages, during peak times when the grid is under pressure, or to avoid peak pricing. Further, the airport is expanding the use of demand response to optimize electricity demand during peak times. All of these initiatives will reduce vulnerability to service interruptions, price fluctuations, and physical damage caused by storms or extreme events.

Energy and Emissions Standards for Buildings: All new construction and renovation projects at DFW will be required to meet sustainability performance targets detailed in an updated Green Building Standard (GBS). The standard will require third-party verification of energy performance, management, and renewable energy production. The GBS will require design teams to develop an energy model demonstrating how new buildings and major renovations will achieve a targeted reduction in energy consumption as compared to a conventional energy code. This will ensure buildings are designed and retrofitted to maximize efficiency. Enhanced commissioning and energy monitoring systems will be required to ensure ongoing verification of energy performance once buildings are operational.

2.4 City of Dallas Climate Action Plan

The City of Dallas has implemented a Comprehensive Environmental and Climate Action Plan ("Climate Action Plan")[3] that was developed in May 2020 with eight goals and corresponding objectives to reduce GHG emissions and mitigate the impacts of climate change locally. The plan provides recommendations for specific actions that the city plans to undertake to achieve its stated targets.

Action B2 of the Climate Action Plan sets goals for the rating level achieved by each local airport under the Airport Carbon Accreditation program. This ongoing action, with benefits and co-benefits including mitigation and cost savings, intends to maintain DFW's current Level 4+ accreditation. Relevant actions include incorporating solar panels on airport garages as feasible to reduce overall carbon footprint, as well as acquiring carbon offsets for remaining emissions sources under DFW's control. The City of Dallas and DFW Airport work in collaboration to maintain DFW's Level 4+ accreditation.

The sustainability measures undertaken and proposed by DFW Airport, as described in section 2.3 above, are consistent with the Dallas Climate Action Plan.

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[3] https://www.dallasclimateaction.com/

2.5 Existing Conditions at DFW Airport

The Existing Conditions for GHG emissions for DFW were estimated based on existing aircraft operations and airport traffic activity in 2022. Detailed information on operations and emissions methodology is provided separately (Ramboll, 2023).

The Existing Conditions aircraft GHG emissions inventory includes emissions associated with taxi-in, taxi-out, and in-flight operations calculated from FAA's state of the art tool for evaluation aircraft noise and emissions – the Aviation Environmental Design Tool (AEDT). The emissions calculated represent the maximum extent of the standard flight profiles available in AEDT (Departures to 10,000 feet and Arrivals from 6,000 feet). Emissions from auxiliary power units (APU) and ground support equipment (GSE) were calculating following the methods provided in Appendix C of the FAA Aviation Emissions and Air Quality Handbook. Surface vehicle traffic also contributes to operational emissions at the airport such as those generated from passengers, employees and material delivery travel to, from, and within the airport.

Table 2-1 provides the operational emissions for all operations for the Existing Conditions.

Table 2-1. Total Operational Emissions for Existing Condition (CY2022)

Calendar Year	Emissions Source	Operations Emissions (tons/year)			
		CO_2	CH_4	N_2O	CO_2e
2022	Aircraft	1,119,229	--	35.4	1,128,900
2022	APU and GSE	52,593	1.7	1.7	53,183
2022	Vehicle traffic	241,190	34.0	2.1	244,568
	TOTAL	1,413,012	35.7	39.2	1,426,651

Note: These emissions are based on the aircraft operations provided in Ramboll (2023) with data from HMMH. Carbon dioxide equivalents (CO2e) were calculated using the 20-year global warming potential of each GHG from the Sixth Assessment Report (AR6) of the IPCC (2021), namely CO_2=1, CH_4= 82.5, N_2O = 273. APU = Auxiliary Power Unit; GSE = Ground Support Equipment.

3. Environmental Consequences

3.1 No Action Alternative

The CTA No Action Alternative would retain the current airport facilities, plus any projects approved or near approval, such as the 19th Street Cargo Redevelopment Project, which is expected to be operational in 2025. Under the No Action Alternative, there would be no project-related construction emissions, and thus, no Project-related GHG emissions. All No Action emissions would be associated with the level and nature of aircraft operations in the future time periods.

Under the 2026 CTA No Action Alternative, there would be no changes to the use of the existing gates at DFW and overall operational levels would grow to over 810,000 operations. Under the 2031 No Action Alternative, there would be no changes to the use of existing gates at DFW such that passenger operations would be constrained due to lack of sufficient facilities. Overall airport operational levels would grow at a minimal growth rate to over 820,000 operations. Under the 2036 No Action Alternative, there would be no changes to the use of existing gates at DFW, limiting further growth to about 830,000 operations.

It should be noted that when DFW does not have sufficient gates to meet forecast demand, the Airport would function at or near gate capacity during most hours of the day. When airports operate at or near gate capacity, those conditions are likely to result in additional taxi/idling/delay time as aircraft await opening of a gate. Since detailed simulation data was not available to account for an exact taxi/idle/delay time, no attempt was made to capture that additional time in the emissions evaluation. Therefore, the No Action alternative aircraft emissions are conservatively low since they do not include the additional taxi/idle/delay time.

The operational phase GHG emissions inventory for the No Action Alternative is shown in Table 3-1 for 2026, 2027, 2028, 2031, and 2036. Emissions for 2027 and 2028 were obtained from linear interpolation between years 2026 and 2031. Aircraft emissions are shown for CO_2 and N_2O; emissions of CH_4 are expected to be negligible. Detailed information on operations and emissions methodology is provided under separate cover (Ramboll, 2023).

Table 3-1. No Action Alternative GHG Emissions Inventory

Project Year	Emissions Source	Operations Emissions (tons/year)			
		CO_2	CH_4	N_2O	CO_2e
2026	Aircraft	1,503,518	--	47.6	1,516,509
2026	APU and GSE	64,947	2.1	2.0	65,676
2026	Vehicle traffic	277,226	42	2.2	281,319
2026	**Total**	**1,845,691**	**44.1**	**51.8**	**1,863,503**
2027	Aircraft	1,509,469	--	47.8	1,522,511
2027	APU and GSE	65,105	2.1	2.0	65,835
2027	Vehicle traffic	274,678	43.0	2.1	278,782
2027	**Total**	**1,849,252**	**45.1**	**51.9**	**1,867,128**
2028	Aircraft	1,515,420	--	48.0	1,528,514
2028	APU and GSE	65,262	2.1	2.0	65,995
2028	Vehicle traffic	272,130	43	2.0	276,246
2028	**Total**	**1,852,812**	**45.1**	**52.0**	**1,870,754**
2031	Aircraft	1,533,273	--	48.5	1,546,521
2031	APU and GSE	65,736	2.1	2.1	66,473
2031	Vehicle traffic	264,487	44	1.9	268,636
2031	**Total**	**1,863,496**	**46.1**	**52.5**	**1,881,631**
2036	Aircraft	1,550,706	--	49.1	1,564,105
2036	APU and GSE	66,694	2.1	2.1	67,443
2036	Vehicle traffic	258,626	45	1.9	262,877
2036	**Total**	**1,876,026**	**47.1**	**53.1**	**1,894,424**

Notes: Aircraft emissions reflect operations under 10,000 feet on departure and arrivals from 6.000 feet as generated by AEDT. Data from Ramboll (2023) and HMMH. Carbon dioxide equivalents (CO2e) were calculated using the 20-year global warming potential of each GHG from the Sixth Assessment Report (AR6) of the IPCC (2021), namely CO_2=1, CH_4= 82.5, N_2O = 273. APU = Auxiliary Power Unit; GSE = Ground Support Equipment.

3.2 Proposed Action

The construction and operational GHG emissions inventory for the Proposed Action is shown in **Table 3-2** for years 2024, 2025, 2026, 2027, 2028, 2031 (buildout plus five years) and 2036 (buildout plus 10 years). Construction would occur during 2024-2028 while operational emissions would be present from 2026 onwards. Operational emissions for 2027 and 2028 were obtained from linear interpolation between years 2026 and 2031. Detailed information is provided separately on construction sources, and operations and emissions methodology (Ramboll, 2023).

Table 3-2. Proposed Action GHG Emissions Inventory[4]

Project Year	Emissions Source	Construction Emissions (tons/year)				Operations Emissions (tons/year)				Total Emissions (Construction + Operations) (tons/year)			
		CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O	CO_2e
2024	Vehicle traffic	16,849	0.43	0.12	16,918	--	--	--	--	16,849	0.43	0.12	16,918
2024	Non-road	3,330	0.34	0.16	3,403	--	--	--	--	3,330	0.34	0.16	3,403
2024	**Total**	**20,179**	**0.77**	**0.28**	**20,321**	--	--	--	--	**20,179**	**0.77**	**0.28**	**20,321**
2025	Vehicle traffic	36,092	0.96	0.29	36,249	--	--	--	--	36,092	0.96	0.29	36,249
2025	Non-road	5,764	0.68	0.28	5,896	--	--	--	--	5,764	0.68	0.28	5,896
2025	**Total**	**41,856**	**1.64**	**0.57**	**42,145**	--	--	--	--	**41,856**	**1.64**	**0.57**	**42,145**
2026	Aircraft	--	--	--	--	1,516,985	-	48.01	1,530,092	1,516,985	0	48.0	1,530,092
2026	APU and GSE	--	--	--	--	65,876	2.12	2.07	66,616	65,876	2.1	2.1	66,616
2026	Vehicle traffic	16,562	0.38	0.12	16,625	277,427	43	2.20	281,523	293,989	43.4	2.3	298,148
2026	Non-road	3,090	0.39	0.15	3,162	--	--	--	--	3,090	0.4	0.2	3,162
2026	**Total**	**19,652**	**0.77**	**0.27**	**19,787**	**1,860,288**	**45.12**	**52.28**	**1,878,231**	**1,879,940**	**45.9**	**52.5**	**1,898,018**
2027	Aircraft	--	--	--	--	1,546,305	-	48.94	1,559,665	1,546,305	0	48.9	1,559,665
2027	APU and GSE	--	--	--	--	67,111	2.16	2.11	67,864	67,111	2.2	2.1	67,864
2027	Vehicle traffic	3,113	0.07	0.02	3,125	279,102	44	2.10	283,276	282,215	44.1	2.1	286,401
2027	Non-road	942	0.14	0.05	966	--	--	--	--	942	0.1	0.1	966
2027	**Total**	**4,055**	**0.21**	**0.07**	**4,091**	**1,892,518**	**46.16**	**53.15**	**1,910,805**	**1,896,573**	**46.4**	**53.2**	**1,914,896**
2028	Aircraft	--	--	--	--	1,575,624	-	49.87	1,589,238	1,575,624	0	49.9	1,589,238
2028	APU and GSE	--	--	--	--	68,345	2.20	2.14	69,113	68,345	2.2	2.1	69,113
2028	Vehicle traffic	1,659	0.04	0.01	1,666	280,777	45	2.10	285,028	282,436	45.0	2.1	286,694
2028	Non-road	379	0.09	0.02	391	--	--	--	--	379	0.1	0	391
2028	**Total**	**2,038**	**0.13**	**0.03**	**2,057**	**1,924,747**	**47.20**	**54.11**	**1,943,379**	**1,926,785**	**47.3**	**54.1**	**1,945,436**
2031	Aircraft	--	--	--	--	1,663,583	-	52.65	1,677,957	1,663,583	0	52.7	1,677,957
2031	APU and GSE	--	--	--	--	72,049	2.31	2.26	72,858	72,049	2.3	2.3	72,858
2031	Vehicle traffic	--	--	--	--	285,801	48	2	290,284	285,801	48.0	2.0	290,284
2031	Non-road	--	--	--	--	--	--	--	--	0	0	0	0
2031	**Total**	**-**	**-**	**-**	**-**	**2,021,433**	**50.31**	**56.91**	**2,041,099**	**2,021,433**	**50.3**	**56.9**	**2,041,099**
2036	Aircraft	--	--	--	--	1,817,104	-	57.51	1,832,804	1,817,104	0.0	57.5	1,832,804
2036	APU and GSE	--	--	--	--	78,464	2.52	2.46	79,345	78,464	2.5	2.5	79,345
2036	Vehicle traffic	--	--	--	--	299,134	52	2.20	304,052	299,134	52.0	2.2	304,052
2036	Non-road	--	--	--	--	--	--	--	--	0	0	0	0
2036	**Total**	**-**	**-**	**-**	**-**	**2,194,702**	**54.52**	**62.17**	**2,216,201**	**2,194,702**	**54.5**	**62.2**	**2,216,201**

Notes: Years 2024 and 2025 have construction only and no operations. Aircraft emissions reflect operations under 10,000 feet on departure and arrivals from 6.000 feet as generated by AEDT. Data from Ramboll (2023) and HMMH. Carbon dioxide equivalents (CO2e) were calculated using the 20-year global warming potential of each GHG from the Sixth Assessment Report (AR6) of the IPCC (2021), namely CO_2=1, CH_4= 82.5, N_2O = 273. APU = Auxiliary Power Unit; GSE = Ground Support Equipment.

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[4] Project year 2024 and 2025 are for construction only.

3.3 Project-Related Emissions

The net GHG emissions from the Proposed Action were calculated from the difference between the Proposed Action Alternative emissions and the No Action Alternative (**Table 3-3**).

Table 3-3. Net GHG Emissions Due to the Project (Proposed Action – No Action Alternative)[4]

Project Year	Emissions Source	Construction Emissions (tons/year)				Operations Emissions (tons/year)				Total Emissions (Construction + Operations) (tons/year)			
		CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O	CO_2e	CO_2	CH_4	N_2O	CO_2e
2024	Vehicle traffic	16,849	0.43	0.12	16,918	--	--	--	--	16,849	0.43	0.12	16,918
2024	Non-road	3,330	0.34	0.16	3,403	--	--	--	--	3,330	0.34	0.16	3,403
2024	**Total**	**20,179**	**0.77**	**0.28**	**20,321**	--	--	--	--	**20,179**	**0.77**	**0.28**	**20,321**
2025	Vehicle traffic	36,092	0.96	0.29	36,249	--	--	--	--	36,092	0.96	0.29	36,249
2025	Non-road	5,764	0.68	0.28	5,896	--	--	--	--	5,764	0.68	0.28	5,896
2025	**Total**	**41,856**	**1.64**	**0.57**	**42,145**	--	--	--	--	**41,856**	**1.64**	**0.57**	**42,145**
2026	Aircraft	--	--	--	--	13,467	-	0.43	13,583	13,467	--	0.43	13,583
2026	APU and GSE	--	--	--	--	930	0.04	0.03	940	65,876	2.12	2.07	66,616
2026	Vehicle traffic	16,562	0.38	0.12	16,625	201	1	-	204	16,763	1.38	0.12	16,829
2026	Non-road	3,090	0.39	0.15	3,162	--	-	-	--	3,090	0.39	0.15	3,162
2026	**Total**	**19,652**	**0.77**	**0.27**	**19,787**	**14,598**	**1.04**	**0.45**	**14,728**	**34,250**	**1.81**	**0.72**	**34,515**
2027	Aircraft	--	--	--	--	36,836	-	1.17	37,154	36,836	-	1.17	37,154
2027	APU and GSE	--	--	--	--	2,006	0.07	0.06	2,029	2,006	0.07	0.06	2,029
2027	Vehicle traffic	3,113	0.07	0.02	3,125	4,424	1	-	4,494	7,537	1.07	0.02	7,619
2027	Non-road	942	0.14	0.05	966	--	-	-	--	942	0.14	0.05	966
2027	**Total**	**4,055**	**0.21**	**0.07**	**4,091**	**43,266**	**1.07**	**1.23**	**43,677**	**47,321**	**1.28**	**1.30**	**47,768**
2028	Aircraft	--	--	--	--	60,204	-	1.91	60,724	60,204	-	1.91	60,724
2028	APU and GSE	--	--	--	--	3,083	0.11	0.10	3,118	68,345	2.20	2.14	69,113
2028	Vehicle traffic	1,659	0.04	0.01	1,666	8,647	2	0.10	8,782	10,306	2.04	0.11	10,448
2028	Non-road	379	0.09	0.02	391	--	-	-	--	379	0.09	0.02	391
2028	**Total**	**2,038**	**0.13**	**0.03**	**2,057**	**71,934**	**2.11**	**2.10**	**72,624**	**73,972**	**2.24**	**2.13**	**74,681**
2031	Aircraft	--	--	--	--	130,310	-	4.12	131,436	130,310	-	4.12	131,436
2031	APU and GSE	--	--	--	--	6,313	0.21	0.20	6,384	72,049	2.31	2.26	72,858
2031	Vehicle traffic	--	--	--	--	21,314	4	0.10	21,648	21,314	4.00	0.10	21,648
2031	Non-road	--	--	--	--	--	-	-	--	-	-	-	-
2031	**Total**	--	--	--	--	**157,937**	**4.21**	**4.42**	**159,468**	**157,937**	**4.21**	**4.42**	**159,468**
2036	Aircraft	--	--	--	--	266,398	-	8.43	268,699	266,398	-	8.43	268,699
2036	APU and GSE	--	--	--	--	11,770	0.38	0.37	11,902	78,464	2.52	2.46	79,345
2036	Vehicle traffic	--	--	--	--	40,508	7	0.30	41,175	40,508	7.00	0.30	41,175
2036	Non-road	--	--	--	--	--	-	-	--	-	-	-	-
2036	**Total**	--	--	--	--	**318,676**	**7.38**	**9.10**	**321,777**	**318,676**	**7.38**	**9.10**	**321,777**

Notes: Aircraft emissions reflect operations under 10,000 feet on departure and arrivals from 6.000 feet as generated by AEDT. Data from Ramboll (2023) and HMMH. Carbon dioxide equivalents (CO2e) were calculated using the 20-year global warming potential of each GHG from the Sixth Assessment Report (AR6) of the IPCC (2021), namely CO_2=1, CH_4= 82.5, N_2O = 273. APU = Auxiliary Power Unit; GSE = Ground Support Equipment.

3.4 Social Cost of Greenhouse Gases due to the Project

The "social cost of carbon," "social cost of nitrous oxide," and "social cost of methane" – together, the "social cost of greenhouse gases" (SC-GHG), are estimates of the monetized damages associated with incremental increases in GHG emissions in a given year.

On January 20, 2021, President Biden issued E.O. 13990, Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis.[5] Section 1 of E.O. 13990 establishes an Administration policy to, among other things, listen to the science; improve public health and protect our environment; ensure access to clean air and water; reduce greenhouse gas emissions; and bolster resilience to the impacts of climate change.[6] Consistent with E.O. 13990, the Council on Environmental Quality (CEQ) issued interim NEPA Guidance on Consideration of Greenhouse Gas Emissions and Climate Change[7]. This guidance, effective upon publication, builds upon and updates the CEQ's 2016 Final Guidance for Federal Departments and Agencies on Consideration of Greenhouse Gas Emissions and the Effects of Climate Change in National Environmental Policy Act Reviews. While CEQ works on updated guidance, it has instructed agencies to consider and use all tools and resources available to them in assessing GHG emissions and climate change effects including recommending that agencies provide additional context for GHG emissions through the use of social cost of GHG estimates.[8]

Regarding the use of Social Cost of Carbon or other monetized costs and benefits of GHGs, the 2016 GHG Guidance noted that NEPA does not require monetizing costs and benefits.[9] It also noted that "the weighing of the merits and drawbacks of the various alternatives need not be displayed using a monetary cost benefit analysis and should not be when there are important qualitative considerations."[10]

Section 5 of E.O. 13990 emphasized how important it is for federal agencies to "capture the full costs of greenhouse gas emissions as accurately as possible, including by taking global damages into account" and established an Interagency Working Group on the Social Cost of Greenhouse Gases (the "IWG"). [11]"). In February of 2021, the IWG published Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide: Interim Estimates under Executive Order 13990 (IWG, 2021).[12] This is an interim report that updated previous guidance from 2016.

In accordance with this direction, this subsection provides estimates of the monetary value of changes in GHG emissions that could result from the proposed action. Such analysis should not be construed to mean a cost determination is necessary to address potential impacts of GHGs associated with specific alternatives. These emissions values were monetized; however, they do not constitute a complete cost-benefit analysis, nor do the SC-GHG numbers present a direct comparison with other impacts analyzed in the EA.

For Federal agencies, the best currently available estimates of the SC-GHG are the interim estimates of the social cost of carbon dioxide (SC-CO_2), methane (SC-CH_4), and nitrous oxide (SC-N_2O) developed by the

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[5] 86 FR 7037 (Jan. 25, 2021).

[6] Id., sec. 1.

[7] 86 FR 1196 (Jan. 9, 2023)

[8] Id.

[9] 2016 GHG Guidance, p. 32, available at: https://ceq.doe.gov/docs/ceq-regulations-and-guidance/nepa_final_ghg_guidance.pdf

[10] Id.

[11] E.O. 13990, Sec. 5.

[12] https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbonMethaneNitrousOxide.pdf

White House's Interagency Working Group (IWG) on the SC-GHG. Select estimates are published in the Technical Support Document (IWG 2021)[13] and the complete set of annual estimates are available on the Office of Management and Budget's website.[14] The IWG's SC-GHG estimates are based on complex models describing how GHG emissions affect global temperatures, sea level rise, and other biophysical processes; how these changes affect society through, for example, agricultural, health, or other effects; and monetary estimates of the market and nonmarket values of these effects. One key parameter in the models is the discount rate, which is used to estimate the present value of the stream of future damages associated with emissions in a particular year. A higher discount rate assumes that future benefits or costs are more heavily discounted than benefits or costs occurring in the present (i.e., future benefits or costs are a less significant factor in present-day decisions). The current set of interim estimates of SC-GHG have been developed using three different annual discount rates: 2.5%, 3%, and 5% (IWG 2021).

As expected with such a complex model, there are multiple sources of uncertainty inherent in the SC-GHG estimates. Some sources of uncertainty relate to physical effects of GHG emissions, human behavior, future population growth and economic changes, and potential adaptation (IWG 2021). To better understand and communicate the quantifiable uncertainty, the IWG method generates several thousand estimates of the social cost for a specific gas, emitted in a specific year, with a specific discount rate. These estimates create a frequency distribution based on different values for key uncertain climate model parameters. The shape and characteristics of that frequency distribution demonstrate the magnitude of uncertainty relative to the average or expected outcome.

To further address uncertainty, the IWG recommends reporting four SC-GHG estimates in any analysis. Three of the SC-GHG estimates reflect the average damages from the multiple simulations at each of the three discount rates. The fourth value represents higher-than-expected economic impacts from climate change. Specifically, it represents the 95th percentile of damages estimated, applying a 3% annual discount rate for future economic effects. This is a low probability, but high damage scenario, represents an upper bound of damages within the 3% discount rate model. The estimates below follow the IWG recommendations.

The annual SC-GHGs associated with estimated Project-related emissions (calculated from the difference between the Proposed Action GHG emissions and the No Action Alternative) are shown in **Table 3-4**. These estimates represent the present value of future market and nonmarket costs associated with CO_2, CH_4, and N_2O emissions. Estimates are calculated based on IWG estimates of social cost per metric ton of emissions for a given emissions year and the estimates of emissions in each year. They are rounded to the nearest $1,000. The estimated social cost of GHG associated with the Proposed Action vary depending on the discount rate and whether construction and/or operations occur.

The social costs provided are estimates only and are subject to change depending on a variety of factors. They are provided for disclosure and context. Accordingly, there can be no assurance that such costs will actually result. Moreover, the estimates of emissions, and the associated social costs, do not reflect the actions that are being taken locally and internationally to consider reductions in aviation-related greenhouse gas emissions. Therefore, these estimates are considered potentially conservatively high.

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[13] IWG 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide, Interim Estimates under Executive Order 13990. Interagency Working Group on Social Cost of Greenhouse Gases, February 2021.

[14] https://www.whitehouse.gov/omb/information-regulatory-affairs/regulatory-matters/#scghgs

Table 3-4. Estimated Social Cost of Greenhouse Gases from Project-Related Emissions

Greenhouse Gases (GHG)	**Present Value of Estimated SC-GHG (in 2020$) due to Project Emissions**			
	Average, 5%	**Average, 3%**	**Average 2.5%**	**95th Percentile, 3%**
2024 CO_2	$316,000	$1,084,000	$1,607,000	$3,245,000
2024 CH_4	$1,000	$1,000	$2,000	$3,000
2024 N_2O	$2,000	$5,000	$8,000	$14,000
2024 Total	**$318,000**	**$1,091,000**	**$1,617,000**	**$3,263,000**
2025 CO_2	$642,000	$2,226,000	$3,305,000	$6,674,000
2025 CH_4	$1,000	$3,000	$3,000	$7,000
2025 N_2O	$4,000	$11,000	$16,000	$29,000
2025 Total	$647,000	**$2,240,000**	**$3,324,000**	**$6,710,000**
2026 CO_2	$515,000	$1,802,000	$2,680,000	$5,412,000
2026 CH_4	$1,000	$3,000	$4,000	$8,000
2026 N_2O	$4,000	$14,000	$20,000	$37,000
2026 Total	**$521,000**	**$1,819,000**	**$2,704,000**	**$5,457,000**
2027 CO_2	$697,000	$2,462,000	$3,668,000	$7,407,000
2027 CH_4	$1,000	$2,000	$3,000	$5,000
2027 N_2O	$8,000	$25,000	$36,000	$65,000
2027 Total	**$705,000**	**$2,489,000**	**$3,707,000**	**$7,478,000**
2028 CO_2	$1,066,000	$3,805,000	$5,680,000	$11,466,000
2028 CH_4	$2,000	$4,000	$5,000	$10,000
2028 N_2O	$12,000	$40,000	$59,000	$106,000
2028 Total	**$1,080,000**	**$3,849,000**	**$5,744,000**	**$11,582,000**
2031 CO_2	$2,132,000	$7,843,000	$11,776,000	$23,755,000
2031 CH_4	$3,000	$7,000	$9,000	$18,000
2031 N_2O	$24,000	$81,000	$121,000	$215,000
2031 Total	**$2,159,000**	**$7,931,000**	**$11,906,000**	**$23,988,000**
2036 CO_2	$3,864,000	$14,892,000	$22,576,000	$45,496,000
2036 CH_4	$4,000	$11,000	$15,000	$31,000
2036 N_2O	$45,000	$159,000	$240,000	$424,000
2036 Total	**$3,913,000**	**$15,063,000**	**$22,832,000**	**$45,951,000**

Note: These are estimates subject to several uncertainties; there can be no assurance that such costs will actually result. The estimates of emissions, and the associated social costs, do not reflect the actions that are being taken locally and internationally to consider reductions in aviation-related greenhouse gas emissions. Therefore, these estimates are considered potentially conservatively high.

3.5 GHG Equivalencies

Table 3-5 shows the number of coal-fired power plants, gasoline-powered passenger vehicles, and other more readily understandable emissions sources that would result in the equivalent amount of annual GHG emissions (EPA 2023b) as the average annual GHG emissions due to Project-related emissions. These equivalent emissions were calculated using the Project-related GHG emissions values following EPA (2023b).

Table 3-5. Comparison of the Annual Average Greenhouse Gas Emissions from Project Emissions to Equivalent Annual GHG Emissions Produced, Avoided, or Sequestered from other Common Activities[15]

Year	Average Annual GHG Emissions* due to Project Emissions (metric tons of 20-year CO_2e)	Number of Coal-fired Power Plants (annual emissions produced)	Number of Gasoline Powered Passenger Vehicles (annual emissions produced)	Number of Homes' Electricity Use (annual emissions produced)	Number of Wind Turbines (annual emissions avoided)	Acres of US forests (annual emissions sequestered)
2024	20,321	0.005	4,512	2,555	5.6	24,178
2025	42,145	0.011	9,358	5,300	11.7	50,149
2026	34,515	0.009	7,675	4,347	9.6	41,131
2027	47,768	0.013	10,615	6,012	13.3	56,885
2028	74,681	0.02	16,601	9,402	20.7	88,961
2031	159,468	0.043	35,433	20,068	44.3	189,880
2036	321,777	0.086	71,498	40,494	89.3	383,149

Source: EPA Greenhouse Gas Equivalencies Calculator. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator.
Annual Average greenhouse gas emissions values are derived from CO_2e values reported in Table 3-3.

3.6 Potential Effect of Climate Change on the Region and Project

The potential effect of future temperature increases on heating and cooling loads at DFW was evaluated using high-resolution ("downscaled") climate model projections for DFW and a regression analysis of historical operational data. The following sections provide a summary followed by descriptions of the data and methods used, the projected change in relevant climate indicators under a range of future climate scenarios, and a discussion of impacts on heating and cooling demand.

3.6.1 Summary

Potential future changes in heating and cooling energy demands at DFW due to climate change were evaluated using historical operational and weather data for DFW and high-resolution ("downscaled") climate

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[15] Annual Average Greenhouse Gas Emissions values are derived from CO_2e values report in Table 3-3.

model[16] projections from the National Aeronautics and Space Administration (NASA). The projected change in annual degree days was used to estimate potential changes in energy demand. Degree days represent the energy needed to cool or heat buildings and are calculated as the daily difference between the average outdoor temperature and the standard indoor temperature (65ºF) summed across a year. Heating degree days (HDD) are calculated when the daily average temperature is below 65ºF, while cooling degree days (CDD) are calculated when temperatures are above 65ºF.

Heating and cooling load data for Terminals A, B, C, D, and E were analyzed and compared to observed degree days[17] at DFW for the period October 2020 to September 2022. A strong relationship was found between cooling loads and heating loads and the CDD and HDD, respectively, indicating that degree days are a good indicator of energy consumption for the Project. Then, projected changes in CDD and HDD in 2030 and 2050 were quantified under an intermediate GHG emissions scenario and a high emissions scenario. These scenarios were applied in the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2021) and span a range of potential future climate conditions.

Daily average temperatures were modeled to increase by nearly 2°F by the 2030s and by over 3°F by the 2050s. Although warmer average temperatures will result in lower heating demand, the total energy demand from heating and cooling is projected to increase due to significantly greater cooling needs during the warmer months. The aggregate heating and cooling load is projected to increase by approximately 11 percent by 2030 and 21 percent by 2050 under the high GHG emissions scenario, with slightly smaller increases of approximately 10 and 17 percent under the intermediate scenario.

The methods and results are discussed in detail below.

3.6.2 Data and Methods

The NASA Earth Exchange (NEX) Global Daily Downscaled Projections (GDDP) data set (Thrasher et al., 2022) was used to assess potential changes in the frequency and intensity of extreme heat and heating/cooling demand. The NEX GDDP data set consists of downscaled global climate model (GCM) simulations originally conducted under the Coupled Model Intercomparison Project Phase 6 (CMIP6). Since the spatial resolution of GCMs are generally 100 kilometers (km) or coarser, the downscaling of GCM output to finer scales is desired for local impact analyses. The NEX-GDDP data set was created using the Bias-Correction Spatial Disaggregation (BCSD) method, which consists of a two-step process. First, outputs from each GCM were compared to an observational data set and adjusted such that its distribution matches that of the observations. Second, the spatial detail of the observations was used to interpolate the GCM data to a finer spatial resolution, in this case 25 km. This downscaling process was performed for 35 GCMs under four GHG emissions scenarios called Shared Socioeconomic Pathways (SSPs), which were developed for use in the Sixth Assessment Report (AR6) of the Intergovernmental Panel on Climate Change (IPCC, 2021).

Here, two SSPs were analyzed: an intermediate scenario (SSP2-4.5) and a higher-emissions scenario (SSP3-7.0). The time horizons assessed were a short-term time horizon (2030s, defined as the 2020-2039 average) and a mid-century time horizon (2050, defined as the 2040-2059 average). Baseline conditions, defined as the 1995-2014 average, were used to assess historical climate conditions. Both absolute and

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[16] Climate models are computer simulations of the earth's climate system including the atmosphere, ocean, biosphere and land surface. A climate model is provided with information about how GHG concentrations may change in the future. The climate model then simulates the response of the earth's climate system to the specified changes in GHGs.

[17] Degree days were calculated from historical hourly weather data for NOAA's Dallas/Ft. Worth International AP weather station, WBAN:03927.

percent changes relative to the baseline period were calculated for the median (50th percentile) across models, as well as the 10th and 90th percentile.

The primary indicators analyzed here include cooling degree days (CDDs) and heating degree days (HDDs). For each day, the difference between 65°F and the average daily temperature was computed. The CDD parameter for a given year is defined as the cumulative sum of this difference on days during the year when the average daily temperature is below 65°F. Similarly, the HDD parameter for a given year is the cumulative sum of differences computed on days when the average daily temperature is above 65°F. CDDs and HDDs are often used to assess heating and cooling demands. Lastly, we included daily mean temperature, as well as two other indicators relevant to extreme heat: the number of days per year where the daily maximum temperature exceeds (i) 95°F and (ii) 100°F. While DFW spans two NEX-GDDP grid cells, we show results for the grid cell with a larger percentage change in three out of the five parameters (heating degree days, days above 95°F, and days above 100°F) across both SSP scenarios. The percent differences between the two grid cells are within half a percentage point for CDDs and HDDs and within 5 percentage points for the other two indicators.

Impacts of changes in heating and cooling degree days were translated to impacts of heating and cooling loads through regression analysis. Degree day regression methods are widely used in energy consumption modeling to estimate and analyze the energy needs of buildings and other systems based on external temperature variations. This approach recognizes that a significant portion of energy consumption in many applications, such as heating and cooling in buildings, is influenced by changes in temperature. By quantifying the relationship between temperature and energy consumption, degree day regression methods provide valuable insights for energy planning by providing a practical framework to understand and quantify the impact of temperature fluctuations on energy needs.

Two years of monthly heating and cooling load data combined for Terminals A, B, C, D, and E spanning the period of October 2020 through September 2022 were collected and compared to local degree days for the same period. Energy data was provided by the airport for chilled water (CHW) and heating hot water (HHW) consumption in units of thousands of British thermal units (kBtu) per month. Degree days were calculated from historical hourly weather data for NOAA's Dallas/Ft. Worth International AP weather station, WBAN:03927.

3.6.3 Projected Change in Degree Days and other Temperature Indicators

The annual values for each climate indicator in the baseline period and each future time horizon are provided in **Table 3-6** and **Table 3-7** for the SSP2-4.5 and SSP3-7.0 scenarios, respectively, while monthly HDD and CDD values are provided in Section 4. Changes in the five indicators do not appreciably differ between the two SSP scenarios, with percent differences generally within 5 percentage points. Daily average temperatures are modeled to increase by nearly 2°F by the 2030s and by over 3°F by the 2050s. Annual cooling demands as measured by CDDs are projected to increase 13% from the historical baseline by the 2030s and approximately 25% by the 2050s. Annual heating demands as measured by HDDs are projected to decrease 10-15% by the 2030s and approximately 21% by the 2050s. While the relative changes can be larger for HDDs, annual absolute changes are always larger for CDDs, suggesting a net increase in energy demand.

DFW was modeled to experience roughly two months' worth of days above 95°F and one month above 100°F on average during the baseline period of 1995-2014. In the future, the number of days per year above both temperature thresholds are projected to increase by approximately two weeks by the 2030s and by three to four weeks by the 2050s.

Table 3-6. Annual baseline values and projected change in climate indicators under SSP2-4.5.

Parameter	Description	Units	Baseline (1995-2014)	Change from Baseline (absolute) under SSP2-4.5 Median (10th, 90th percentile)		Change from Baseline (% change) under SSP2-4.5 Median (10th, 90th percentile)	
				2020-2039	**2040-2059**	**2020-2039**	**2040-2059**
Daily Mean Temperature	Daily average temperature, defined as the average of daily maximum and minimum temperatures	°F	67.5	1.87 [1.03, 2.79]	3.08 [2.36, 4.05]	0.36 [0.19, 0.53]	0.58 [0.45, 0.77]
Cooling Degree Days	Cumulative sum of difference between mean daily temperature (Tmean) and 65°F when Tmean > 65°F	°F · Days	2979.12	386.12 [169.28, 623.19]	679.86 [516.73, 929.21]	12.96 [5.68, 20.92]	22.82 [17.34, 31.19]
Heating Degree Days	Cumulative sum of difference between mean daily temperature (Tmean) and 65°F when Tmean < 65°F	°F · Days	2047.51	-302.05 [-403.96, -93.80]	-420.04 [-520.41, -284.25]	-14.75 [-19.73, -4.58]	-20.51 [-25.42, -13.88]
Days above 95°F	Number of days per year with daily maximum temperature above 95°F	Days	61.10	15.13 [7.95, 28.72]	25.25 [17.35, 43.94]	24.77 [13.01, 47.01]	41.33 [28.39, 71.92]
Days above 100°F	Number of days per year with daily maximum temperature above 100°F	Days	27.03	14.35 [6.91, 27.75]	22.80 [15.80, 37.10]	53.08 [25.55, 102.64]	84.34 [58.45, 137.23]

Table 3-7. Annual baseline values and projected change in climate indicators under SSP3-7.0.

Parameter	Description	Units	Baseline (1995-2014)	Change from Baseline (absolute) under SSP3-7.0 Median (10th, 90th percentile)		Change from Baseline (% change) under SSP3-7.0 Median (10th, 90th percentile)	
				2020-2039	2040-2059	2020-2039	2040-2059
Daily Mean Temperature	Daily average temperature, defined as the average of daily maximum and minimum temperatures	°F	67.5	1.67 [0.90, 2.92]	3.37 [2.47, 4.97]	0.32 [0.17, 0.55]	0.64 [0.47, 0.94]
Cooling Degree Days	Cumulative sum of difference between mean daily temperature (Tmean) and 65°F when Tmean > 65°F	°F · Days	2979.12	375.31 [174.29, 539.79]	771.36 [504.18, 951.62]	12.60 [5.85, 18.12]	25.89 [16.92, 31.94]
Heating Degree Days	Cumulative sum of difference between mean daily temperature (Tmean) and 65°F when Tmean < 65°F	°F · Days	2047.51	-212.25 [-413.93, -8.08]	-431.77 [-564.62, -262.35]	-10.37 [-20.22, -0.39]	-21.09 [-27.58, -12.81]
Days above 95°F	Number of days per year with daily maximum temperature above 95°F	Days	61.10	15.07 [4.48, 25.08]	26.35 [15.42, 39.06]	24.66 [7.33, 41.05]	43.13 [25.24, 63.93]
Days above 100°F	Number of days per year with daily maximum temperature above 100°F	Days	27.03	14.35 [6.39, 22.78]	24.25 [13.96, 34.33]	53.08 [23.63, 84.27]	89.71 [51.64, 126.99]

Heating and Cooling Load Projections

Figure 3-1 and **Figure 3-2** include the resulting regressions of cooling load and heating load versus cooling degree days and heating degree days, respectively. The cooling load linear regression results in an R2 of 0.97 and the heating load linear regression results in and R^2 of 0.96, suggesting that degree days are a good indicator of consumption for the facility. **Figure 3-1** and **Figure 3-2** include the historical regression analysis and highlight the strong relationship of weather to consumption.

Using the median degree day forecasts for the various climate model scenarios discussed above and the heating and cooling regression models, annual energy consumption impacts were calculated to gain insight on the anticipated order of magnitude change in cooling and heating loads for the area. Impacts to cooling and heating loads predictably follow the results of the climate modeling with cooling loads increasing and heating loads decreasing from baseline expectations. In aggregate the magnitude of cooling load increases outweighs the heating load decreases resulting in an overall increase in total annual energy consumption. Figure 3-3 presents the anticipated cumulative annual heating and cooling load increase for the median degree day changes of the two climate scenarios (SSP2-4.5, SSP3-7.0) and two future time horizons (2030s, 2050s).

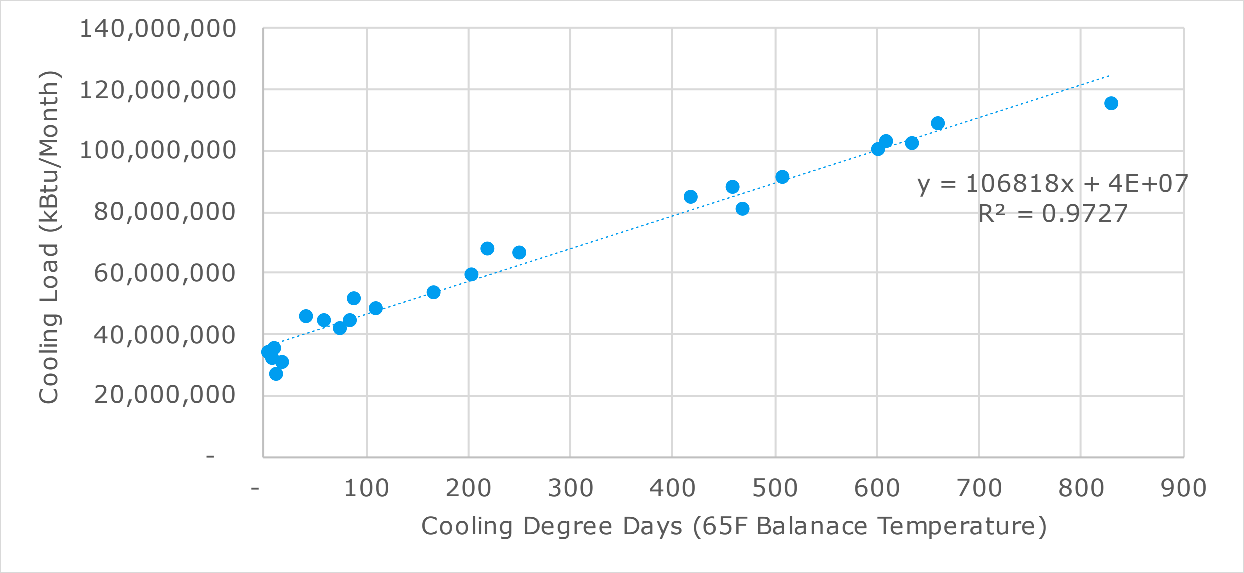

Figure 3-1. Historical monthly cooling load vs cooling degree days.

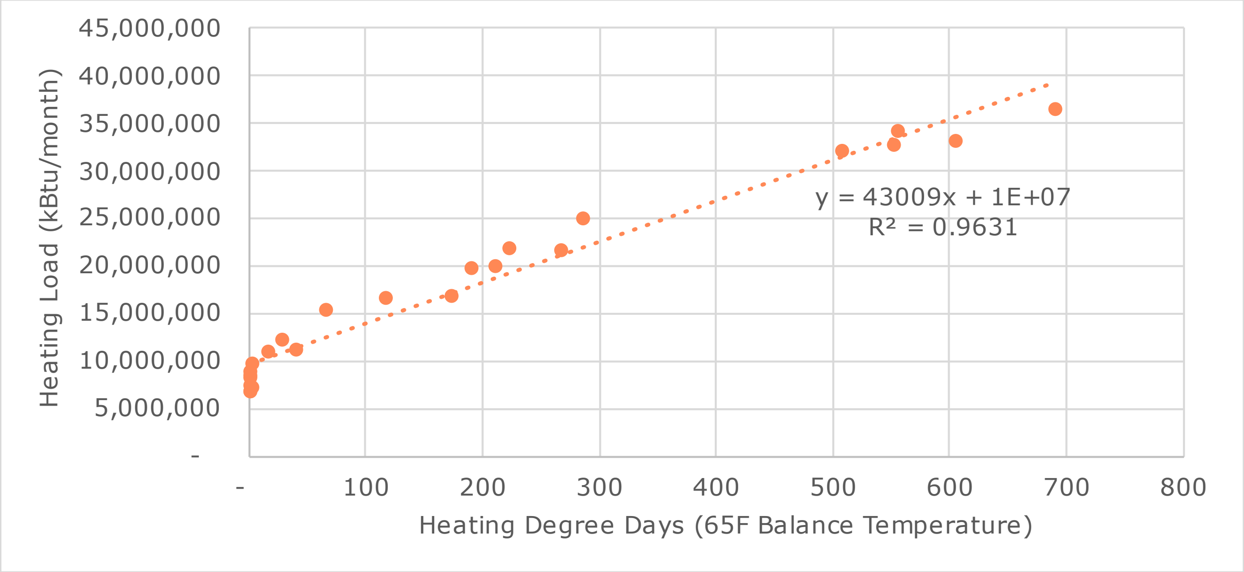

Figure 3-2. Historical monthly heating load vs heating degree days.

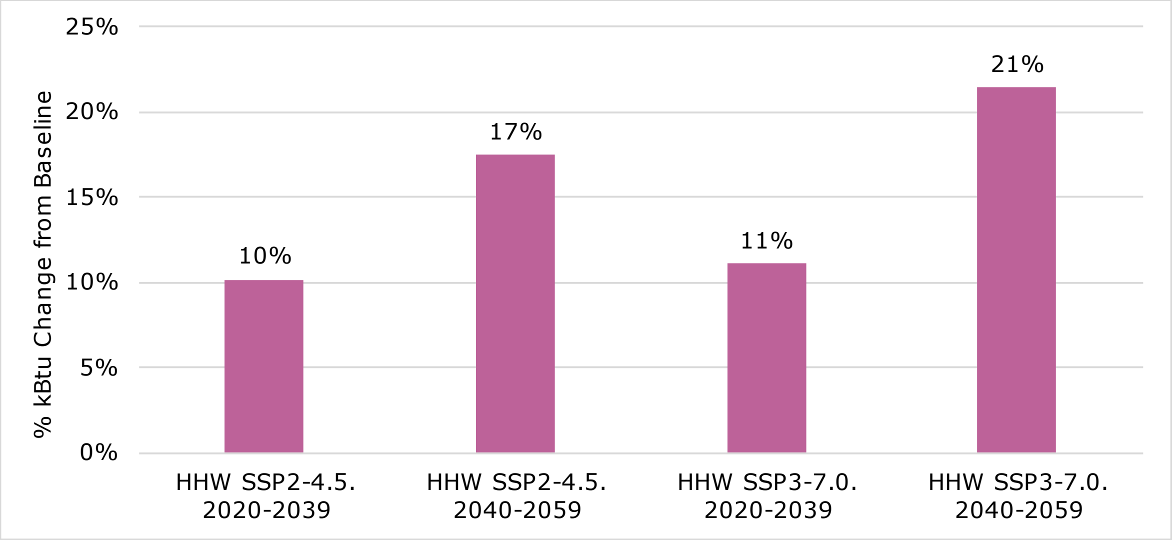

Figure 3-3. Aggregate heating and cooling load impacts.

3.6.4 DFW-related Climate Experience

Since FY2018, DFW has purchased 100% of its electricity from renewable sources, specifically Texas wind farms (DFW 2017). Its primary source of GHG emissions is its natural gas-powered Central Utility Plant (CUP), which provides cooling and heating services to the airport, as well as hotels and other support facilities. A replacement all electric CUP that will be powered by wind-derived electricity is currently being constructed and is set to come online in 2025 (Forte 2023).

As previously mentioned, higher temperatures, especially on hot days where the temperature exceeds 95°F, will lead to decreased demand for heating and increased electricity demand for cooling. In Texas, every 1°C (1.8°F) increase in the average daily temperature above 24°C (75°F) results in a 4% increase in electricity demand (Howarth et al. 2023). In the case of DFW, regression analysis approximation suggests that aggregate heating and cooling loads will increase by 10% to 21%, depending on period of projection and climate case.

Additionally, warmer temperatures lower the efficiency of electricity transmission and distribution systems by reducing the amount of current carried (DOE 2013). Power lines become more prone to sagging due to thermal expansion, heightening the risk of contact with trees, which in turn can lead to fires and blackouts. The risk of blackouts during periods of high temperatures is compounded by the fact that air conditioning use is greatest when transmission losses are greatest, effectively further increasing peak loads due to losses in efficiency.

To increase its resiliency from impacts on the grid, DFW is developing a roadmap for achieving clean and resilient that will include initiatives to increase energy demand flexibility and provide additional onsite generation assets. The airport is researching demand response to balance daily electricity consumption, as well as storage infrastructure, including batteries, to store excess energy that can be used during a service outage, during times of peak loads when the grid is under pressure, or simply to avoid peak pricing (DFW 2022).

4. Supplemental Information

4.1 Monthly Cooling and Heating Degree Day Projections

The projected change in monthly HDDs and CDDs relative to the historical baseline period under the SSP2-4.5 scenarios are provided in **Table 4-1** and **Table 4-2**, respectively. The projected changes in HDDs and CDDs under SSP3-7.0 are provided in **Table 4-3** and **Table 4-4**, respectively.

Table 4-1. Monthly change in heating degree days under SSP2-4.5.

Month	Baseline (1995-2014)	Change from Baseline (absolute) Median (10th, 90th percentile)		Change from Baseline (% change) Median (10th, 90th percentile)	
		2020-2039	2040-2059	2020-2039	2040-2059
January	573.54	-55.33 [-124.4, 3.31]	-70.13 [-155.91, -18.9]	-9.65 [-21.69, 0.58]	-12.23 [-27.18, -3.3]
February	395.33	-62.05 [-102.17, 0.74]	-74.62 [-126.26, 14.97]	-15.7 [-25.84, 0.19]	-18.88 [-31.94, 3.79]
March	220.84	-34.74 [-72.04, 1.24]	-52.46 [-98.3, -13.44]	-15.73 [-32.62, 0.56]	-23.75 [-44.51, -6.08]
April	61.1	-18.38 [-29.59, -3.25]	-26.25 [-38.59, -12.48]	-30.08 [-48.44, -5.32]	-42.97 [-63.17, -20.43]
May	5.62	-1.69 [-6, 0.13]	-3.96 [-6.72, -1.41]	-30.07 [-106.69, 2.35]	-70.47 [-119.46, -25.12]
June	0.07	-0.01 [-0.18, 0.11]	-0.01 [-0.18, 0.04]	-14.45 [-267.46, 165.14]	-13.33 [-267.46, 55.03]
July	0	0 [0, 0]	0 [0, 0]	0 [0, 0]	0 [0, 0]
August	0	0 [0, 0.04]	0 [0, 0]	0 [0, 0]	0 [0, 0]
September	1.74	-0.95 [-2.22, 0.66]	-0.93 [-2.31, 0.08]	-54.47 [-127.6, 37.77]	-53.43 [-132.92, 4.37]
October	47.59	-11.37 [-21.63, -0.95]	-23.22 [-32.93, -13.96]	-23.89 [-45.45, -1.99]	-48.8 [-69.19, -29.34]
November	230.2	-37.66 [-62.89, 5.97]	-66.29 [-101.97, -28.05]	-16.36 [-27.32, 2.59]	-28.8 [-44.3, -12.19]
December	508.03	-56.98 [-116.48, -21.92]	-89.5 [-146.35, -25.75]	-11.22 [-22.93, -4.31]	-17.62 [-28.81, -5.07]

Table 4-2. Monthly change in cooling degree days under SSP2-4.5.

Month	Baseline (1995-2014)	Change from Baseline (absolute) Median (10th, 90th percentile)		Change from Baseline (% change) Median (10th, 90th percentile)	
		2020-2039	2040-2059	2020-2039	2040-2059
January	3.16	1.43 [0.39, 3.95]	2.53 [1.38, 5.68]	45.35 [12.33, 124.91]	80.02 [43.69, 179.7]
February	8.3	3.39 [-0.17, 8.7]	5.36 [0.6, 12.88]	40.81 [-1.99, 104.84]	64.59 [7.26, 155.17]
March	35.65	16.74 [1.19, 31.76]	25.74 [10.9, 37.76]	46.97 [3.33, 89.09]	72.2 [30.57, 105.9]
April	122.67	33.41 [14.85, 62.78]	60.58 [27.46, 96.44]	27.23 [12.1, 51.17]	49.38 [22.39, 78.62]
May	307.0	52.77 [16.07, 84.31]	91.07 [54.94, 137.21]	17.19 [5.24, 27.46]	29.66 [17.9, 44.69]
June	515.1	61.94 [31.1, 104.89]	99.85 [48.09, 153.57]	12.02 [6.04, 20.36]	19.39 [9.34, 29.81]
July	661.8	62.81 [17.19, 109.26]	108.16 [51.51, 168.6]	9.49 [2.6, 16.51]	16.34 [7.78, 25.48]
August	667.88	55.43 [24.28, 92.15]	105.11 [76.92, 157.67]	8.3 [3.64, 13.8]	15.74 [11.52, 23.61]
September	438.27	61.65 [22.81, 92.81]	100.86 [72.67, 146.41]	14.07 [5.21, 21.18]	23.01 [16.58, 33.41]
October	170.97	39.92 [6.73, 76.94]	90.89 [43.53, 152.91]	23.35 [3.94, 45]	53.16 [25.46, 89.44]
November	36.25	16.01 [0.14, 33.62]	33.13 [13.07, 48.53]	44.15 [0.39, 92.72]	91.37 [36.06, 133.85]
December	5.99	3.3 [0.22, 11.27]	6.99 [1.95, 14.08]	55.08 [3.71, 187.95]	116.58 [32.49, 234.87]

Table 4-3. Monthly change in heating degree days under SSP3-7.0.

Month	Baseline (1995-2014)	Change from Baseline (absolute) Median (10th, 90th percentile)		Change from Baseline (% change) Median (10th, 90th percentile)	
		2020-2039	2040-2059	2020-2039	2040-2059
January	573.54	-58.96 [-135.58, 17.62]	-104.19 [-204.91, -48.47]	-10.28 [-23.64, 3.07]	-18.17 [-35.73, -8.45]
February	395.33	-39.83 [-112.87, 26.58]	-100.73 [-158.16, -3.53]	-10.08 [-28.55, 6.72]	-25.48 [-40.01, -0.89]
March	220.84	-40.08 [-67.34, 32.8]	-68.73 [-95.82, -26.63]	-18.15 [-30.49, 14.85]	-31.12 [-43.39, -12.06]
April	61.1	-12.75 [-37.26, -3.62]	-31.77 [-43.81, -17.44]	-20.86 [-60.98, -5.93]	-51.99 [-71.7, -28.55]
May	5.62	-1.64 [-6.27, 1.06]	-3.26 [-7.48, -1.43]	-29.22 [-111.48, 18.84]	-57.99 [-133.04, -25.38]
June	0.07	-0.01 [-0.16, 0.05]	-0.02 [-0.18, 0]	-14.45 [-243.15, 78.99]	-25.06 [-267.46, 0]
July	0	0 [0, 0]	0 [0, 0]	0 [0, 0]	0 [0, 0]
August	0	0 [0, 0]	0 [0, 0]	0 [0, 0]	0 [0, 0]
September	1.74	-0.53 [-2.13, 1.13]	-1.12 [-2.82, 0.43]	-30.71 [-122.15, 64.8]	-64.29 [-161.85, 24.72]
October	47.59	-16.54 [-26.51, -5.54]	-26.18 [-35.38, -14.35]	-34.76 [-55.7, -11.64]	-55.02 [-74.35, -30.16]
November	230.2	-35.44 [-78.36, 2.07]	-81.64 [-98.96, -51.59]	-15.39 [-34.04, 0.9]	-35.47 [-42.99, -22.41]
December	508.03	-66.96 [-116.79, 15.75]	-111.59 [-167.87, -57.72]	-13.18 [-22.99, 3.1]	-21.97 [-33.04, -11.36]

Table 4-4. Monthly change in cooling degree days under SSP3-7.0.

Month	Baseline (1995-2014)	Change from Baseline (absolute) Median (10th, 90th percentile)		Change from Baseline (% change) Median (10th, 90th percentile)	
		2020-2039	2040-2059	2020-2039	2040-2059
January	3.16	1.11 [-0.04, 7.1]	3.98 [1.61, 8.95]	35.03 [-1.22, 224.59]	125.85 [50.78, 283.07]
February	8.3	3.73 [-2.34, 9.04]	9.07 [3.3, 14.74]	44.98 [-28.15, 108.85]	109.25 [39.79, 177.47]
March	35.65	13.96 [-0.16, 32.67]	32.97 [15.97, 52.23]	39.15 [-0.44, 91.64]	92.47 [44.79, 146.5]
April	122.67	44.95 [5.4, 65.15]	74.53 [51.45, 118.05]	36.64 [4.4, 53.11]	60.75 [41.94, 96.23]
May	307	63.12 [14.62, 105.21]	122.91 [67.22, 170.99]	20.56 [4.76, 34.27]	40.04 [21.89, 55.7]
June	515.1	65.11 [5.47, 115.86]	124.88 [69.42, 170.46]	12.64 [1.06, 22.49]	24.24 [13.48, 33.09]
July	661.8	68.3 [4.9, 112.56]	125.16 [75.7, 175.02]	10.32 [0.74, 17.01]	18.91 [11.44, 26.45]
August	667.88	62.25 [24.04, 100.34]	125.33 [89.38, 171.92]	9.32 [3.6, 15.02]	18.77 [13.38, 25.74]
September	438.27	68.9 [31.13, 116.52]	122.52 [89.24, 164.81]	15.72 [7.1, 26.59]	27.96 [20.36, 37.6]
October	170.97	48.84 [20.19, 89.23]	97.32 [57.13, 177.73]	28.57 [11.81, 52.19]	56.92 [33.41, 103.96]
November	36.25	14.14 [-0.05, 36.25]	36.66 [18.32, 63.38]	39 [-0.13, 100]	101.1 [50.53, 174.81]
December	5.99	3.6 [-0.61, 9.39]	7.25 [3.2, 18.38]	60.05 [-10.19, 156.58]	120.9 [53.47, 306.59]

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