APPENDIX Q

Greenhouse Gases and Climate Change Impacts

US 51 (Stoughton Road) North Study Technical Memorandum

Greenhouse Gases and Climate Change Impacts

November 2024

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1.0 Introduction of Greenhouse Gases and Climate Change

Climate change refers to long-term changes in temperature, precipitation, wind patterns and other elements of the Earth's climate system. The Intergovernmental Panel on Climate Change (IPCC) is the international body for assessing the science related to climate change. Climate change in the past has generally occurred gradually over millennia, or more suddenly in response to cataclysmic natural disruptions. The research of the IPCC and other scientists over recent decades now attributes the accelerated rate of climatological changes, observed over the past 150 years, to greenhouse gas (GHG) emissions generated from the production and use of fossil fuels.[1]

The impacts of climate change are being observed in the form of sea level rise, drought, more intense heat, extended and severe fire seasons and historic flooding from changing storm patterns. Climate change does not affect all people equally. Some communities experience disproportionate impacts because of existing vulnerabilities, historical patterns of inequity, socioeconomic disparities and systemic environmental injustices. People who already face the greatest burdens are often the ones affected most by climate change.

Human activities generate GHGs consisting primarily of carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), tetrafluoromethane, hexafluoroethane, sulfur hexafluoride and various hydrofluorocarbons. CO_2 is the most abundant GHG; although CO_2 is a naturally occurring and necessary component of Earth's atmosphere, fossil fuel combustion is the main source of additional, human-generated CO_2 that is the main driver of climate change. In the U.S., transportation is the largest source of GHG emissions, mostly CO_2. In Wisconsin, the electricity sector is the top GHG contributor. Transportation is the second-largest source of GHG emissions in Wisconsin.

The Council on Environmental Quality (CEQ) published interim guidance on January 9, 2023, regarding how to evaluate GHG emissions and climate change under the National Environmental Policy Act (NEPA). According to the interim guidance, when conducting climate change analyses in NEPA reviews, agencies should consider the potential effects of a proposed action on climate change, including by assessing both GHG emissions and reductions from the proposed action, as well as the effects of climate change on a proposed action and its environmental impacts. The CEQ interim guidance does not establish any particular quantity of GHG emissions as "significantly" affecting the quality of the human environment.[2]

The interim guidance also provides considerations to document how GHG emissions impact environmental justice populations. The guidance notes: "Numerous studies have found that environmental hazards (including those driven by climate change) are more prevalent in and pose particular risks to areas where people of color and low-income populations represent a higher fraction of the population compared with the general population."[3] The guidance also notes: "Agencies should be aware of the ongoing efforts to address the effects of climate change on human health and vulnerable communities. Certain groups, including children, the elderly, communities with environmental justice concerns, which often include communities of color, low-income communities, Tribal Nations, Indigenous communities and underserved communities are more vulnerable to climate-related health effects and may face barriers to engaging on issues that disproportionately affect them".[4]

This technical memorandum summarizes the GHG and climate change impact analysis of the US 51 (Stoughton Road) North Study – hereafter referred to as US 51 North Study or Study – following the CEQ interim guidance.[5] Because there are environmental justice populations present in the US 51 North Study corridor, and the interim guidance notes that environmental justice populations are generally at increased risk for climate change-related harms, this technical memorandum also documents the impacts of GHG emissions on environmental justice populations. Environmental justice populations, including minority and low-income populations, are located in the

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[1] The Intergovernmental Panel on Climate Change (IPCC). 2014. Fifth Assessment Report, Changes in Atmospheric Constituents and in Radiative Forcing. https://www.ipcc.ch/assessment-report/ar5/. Accessed 30 May 2024.

[2] Council on Environmental Quality (CEQ). 2023. "National Environmental Policy Act Guidance on Consideration of Greenhouse Gas Emissions and Climate Change." Federal Register. Vol. 88, No. 5. January 9.

[3] Ibid

[4] Ibid

[5] Ibid

Madison metropolitan area. Detailed information on project engagement with environmental justice communities and impacts can be found in Sections 12 and 14 of the Environmental Assessment Template and the Environmental Justice Factor sheet in the Study's Environmental Assessment (EA).

2.0 Project Description

The Wisconsin Department of Transportation (WisDOT) and the Federal Highway Administration (FHWA) are evaluating reconstruction of the US 51 corridor, from WIS 30 in the city of Madison to Interstate 39/90/94 in the town of Burke, Dane County. Figure 2-1 shows the approximate 5.5-mile study corridor. System interchanges are located at both ends of the Study, WIS 30 to the south and I-39/90/94 to the north. There are 14 at grade intersections along US 51 in the study area, including the WIS 30 ramp terminals. The I-39/90/94 interchange and Daentl Road intersection are being studied as part of the I-39/90/94 Corridor Study (US 12/18 Madison to US 12/WIS 16 Wisconsin Dells).

Preferred Alternative

The US 51 North Study preferred alternative is to reconstruct approximately 5.5 miles, one interchange, and improve eleven intersections between WIS 30 and I-39/90/94.

Corridor Summary

- South of WIS 30 to US 151: Reconstruction to a 6-lane urban section, with a potential speed limit reduction, and a shared-use path
- US 151 to Anderson Street: Reconstruction to a 5 to 6 lane urban section with a shared-use paths
- Anderson Street to Kinsman Boulevard: Reconstruction to a 4-lane urban section with shared-use path
- Kinsman Boulevard to Pierstorff Street: Reconstruction to a 4-lane urban section
- Pierstorff Street to Hoepker Road: Reconstruction to a 4-lane rural section and horizontal curve correction
- Hoepker Road to south of I-39/90/94: Reconstruction to a 4-lane rural section with a shared-use path

Intersection Summary

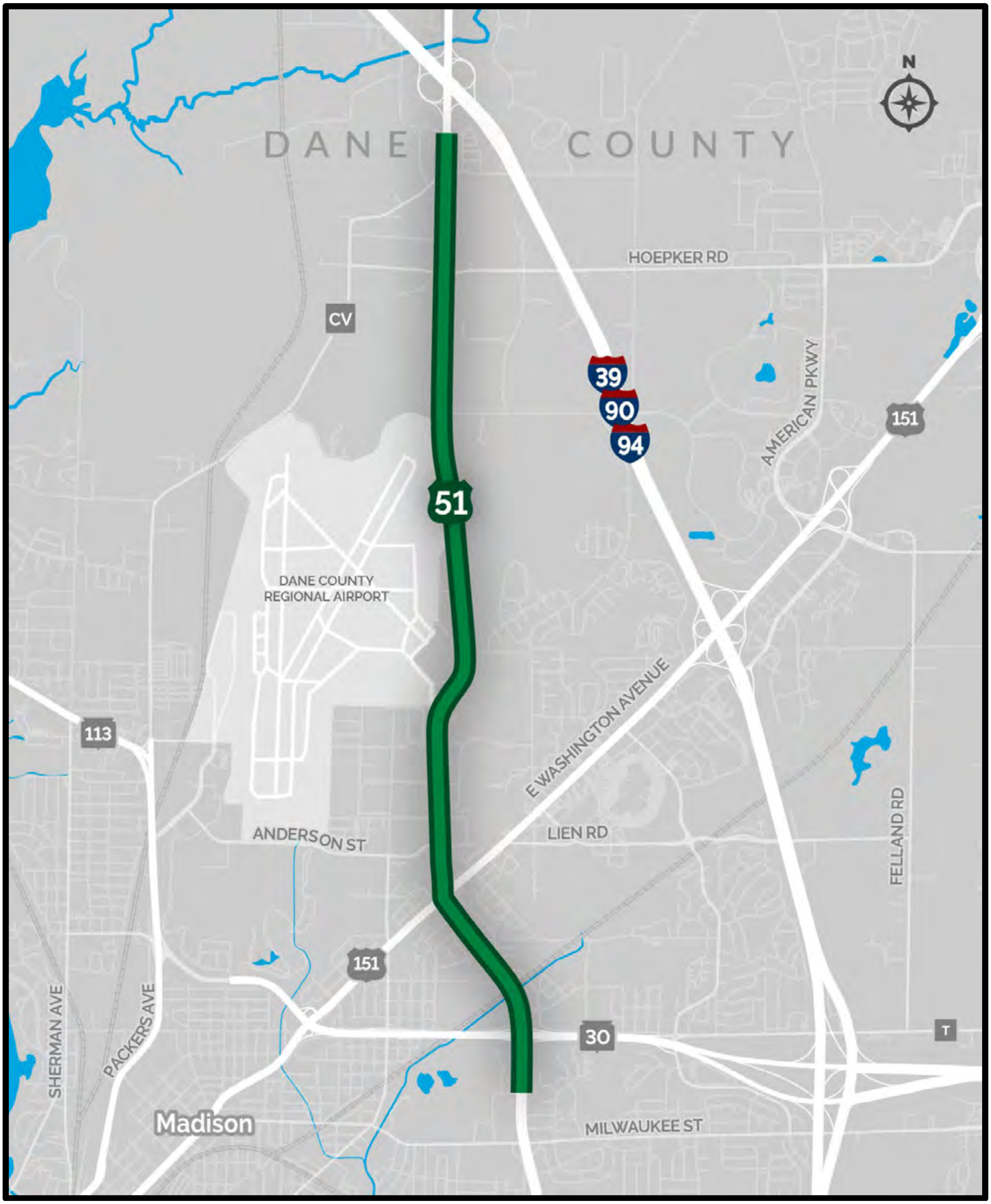
Most intersections within US 51 study area would keep the same or a similar configuration as existing, with improvements for the preferred alternative.

- **WIS 30** would be reconstructed and remain a signalized diamond interchange with improvements. Improvements to the existing condition would include optimized signal timings, additional turn lanes, additional auxiliary lane to Commercial Avenue, extended turn lanes, and a new shared-use path along the east side of US 51 south of WIS 30.
- **Commercial Avenue/Lexington Avenue** would be reconstructed and remain a signalized four-legged intersection with improvements. Improvements to the existing condition would include updated roadway geometry, additional turn lanes, additional auxiliary lane from WIS 30, new railroad signals and gates, additional crosswalks, and provide new shared-use paths along the east side of US 51 and along the east side of Commercial Avenue to the Walmart property and Madison Metro bus stop. This reconstruction would slightly realign the intersection of Lexington Avenue and North Stoughton Service Road to the west.

- **US 151** would be reconstructed and remain an at-grade signalized intersection, along a similar alignment to the existing intersection, with improvements. Under the preferred alternative, US 51 and US 151 would both have three travel lanes in each direction with separated left and right turn lanes. Improved traffic signalization and intersection skew angle would provide turning movements that are more familiar to drivers while also maintaining the urban feel of the area. Additional turn lanes would provide larger left-turn capacity. In addition, the preferred alternative would improve traffic operations, add bicycle and pedestrian crossings at all four legs of the intersection, accommodate additional capacity, and provide a new shared-use path along both sides of US 51 north of the intersection.
- **Anderson Street** would be reconstructed and remain a signalized conventional intersection with improvements. Improvements to the existing condition would include optimized signal timings, improved bicycle and pedestrian crossings, and a new shared-use path along both sides of US 51 south of the intersection and along the east side to the north.
- **Kinsman Boulevard** would be reconstructed and remain a signalized conventional intersection with improvements. Improvements to the existing condition would include optimized signal timings, extended turn lanes, improved dedicated east-west bicycle lanes, improved traffic operations, additional crosswalks, and a new shared-use path along the east side of US 51 to the south of the intersection.
- **Pierstorff Street** would be reconstructed and remain an unsignalized right-in/right-out intersection. Improvements to the existing condition would include extended offset turn lanes and improved median cut-outs for non-motorized US 51 crossings. The S-curve north of this intersection would be reconstructed to meet standards, and Leo Circle would be realigned to accommodate this change.
- **Rieder Road** would reconstruct the existing Rieder Road intersection. It would maintain the existing access and configuration at the intersection. There are no impacts associated with this alternative.
- **Amelia Earhart Drive** would be reconstructed and remain an unsignalized full-access intersection with improvements. Improvements to the existing condition would include an extended northbound US 51 left-turn lane and the addition of a southbound US 51 right-turn lane.
- **Hanson Road** would be reconstructed as a full-access intersection. US 51 would have two travel lanes in each direction and Hanson Road would remain one lane in each direction. The unsignalized intersection would improve traffic operations by providing median-protected deceleration and acceleration lanes for cross-traffic movements, a northbound deceleration lane, and add dedicated turn lanes on Hanson Road.
- **Hoepker Road** would be reconstructed and remain a signalized conventional intersection with improvements. Improvements to the existing condition would include optimized signal timings, extended turn lanes, additional turn lanes, adding crosswalks on all four legs of the intersection, and a new shared-use path along the east side of US 51 to the north of the intersection.
- **Acker Road** would be reconstructed and remain an unsignalized full-access intersection with improvements. Improvements to the existing condition would include extended turn lanes and a new shared-use path along the east side of US 51 to the north of the intersection.
- **County CV** would be reconstructed and remain a signalized conventional intersection with improvements. Improvements to the existing condition would include extended turn lanes, optimized signal timings, and a new shared-use path along the east side of US 51, with crosswalk, to the north of the intersection that would tie into a shared-use path as part of the I-39/90/94 interchange.

As the Study's build alternatives do not propose to add mainline capacity to the roadway, traffic volumes in the future build and No Build scenarios do not vary.

Figure 2-1: US 51 North Study Location



Source: WisDOT, 2024.

3.0 Regulatory Background

3.1. Federal

3.1.1. Regulations

The federal government has taken steps to improve fuel economy and energy efficiency to address climate change and its associated effects. The most important of these were the Energy Policy and Conservation Act of 1975 (42 United States Code Section 6201), as amended by the Energy Independence and Security Act of 2007, and Corporate Average Fuel Economy (CAFE) standards. The National Highway Traffic Safety Administration (NHTSA) of the United States Department of Transportation (USDOT) sets and enforces the CAFE standards based on each manufacturer's average fuel economy for the portion of its vehicles produced for sale in the United States. The United States Environmental Protection Agency (EPA) calculates average fuel economy levels for manufacturers, and also sets related GHG emissions standards under the Clean Air Act. Raising CAFE standards leads automakers to create a more fuel-efficient fleet, which improves our nation's energy security, saves consumers money at the pump and reduces GHG emissions.[6]

NHTSA and EPA have issued a series of regulations to set fuel efficiency and GHG emission standards for vehicles since 2012. In December 2021, EPA published a final rulemaking that raised federal GHG emissions standards for passenger cars and light trucks for model years 2023 through 2026, increasing in stringency each year.[7] The updated GHG emissions standards are anticipated to eliminate more than 3 billion tons of GHG emissions nation-wide through 2050. In June 2024, NHTSA published the final rule establishing new Corporate Average Fuel Economy (CAFE) standards for model years 2027 through 2031 passenger cars and light-duty trucks, which are anticipated to reduce fuel use by more than 70 billion gallons through 2050 and reduce fuel costs by nearly $23 billion for drivers.[8]

On March 29, 2024, EPA issued a final rule "Greenhouse Gas Emissions Standards for Heavy-Duty Vehicles – Phase 3" to revise existing standards to reduce greenhouse gas emissions from heavy-duty vehicles in model year 2027 and set new, more stringent standards for model years 2028 through 2032. In June 2024, NHTSA published the final rule for heavy-duty pickup trucks and vans, which will increase fuel efficiency rates at 10% per year for model years 2030 through 2032 and 8% per year in model years 2033 through 2035.[8] The final standards for heavy-duty vehicles will avoid approximately 1 billion metric tons of GHG emissions from 2027 through 2055, making an important contribution to efforts to limit climate change and its impacts such as heat waves, drought, sea level rise, extreme climate and weather events, coastal flooding, and wildfires.[9]

3.1.2. National Environmental Policy Act Context

NEPA (42 United States Code Part 4332) requires federal agencies to assess the environmental effects of their proposed actions prior to deciding on the action or project. To date, no nationwide mobile-source GHG reduction targets have been established, nor have any regulations or legislation been enacted specifically to address climate change and GHG emissions reduction at the project level.

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[6] *United States Department of Transportation (USDOT). 2014. Corporate Average Fuel Economy (I) Standards. https://www.transportation.gov/mission/sustainability/corporate-average-fuel-econIcafe-standards. Accessed 30 May 2024.*

[7] *United States Environmental Protection Agency (EPA). 2022. Final Rule to Revise Existing National GHG Emissions Standards for Passenger Cars and Light Trucks Through Model Year 2026. https://www.epa.gov/regulations-emissions-vehicles-and-engines/final-rule-revise-existing-national-ghg-emissions. Accessed 30 May 2024.*

[8] National Highway Traffic Safety Administration (NHTSA). 2024. NHTSA Announces Final Rule for CAFÉ and HDPUV Standards. *https://www.nhtsa.gov/laws-regulations/corporate-average-fuel-economy#75896. Accessed* 7 August 2024.

[9] *United States Environmental Protection Agency (EPA). 2024. Final Standards to Reduce Greenhouse Gas Emissions from Heavy Duty Vehicles for Model Year 2027 and Beyond. https://www.epa.gov/system/files/documents/2024-04/420f24018.pdf. Accessed 30 May 2024.*

In January 2021, President Biden issued the "Executive Order on Protecting Public Health and the Environment and Restoring Science to Tackle the Climate Crisis" (Executive Order [EO] 13990). EO 13990 calls for all federal agencies to review climate-related regulations and actions taken between 2017 and 2021 and tasks CEQ with updating its "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" (81 FR 51866). On January 9, 2023, CEQ issued interim "National Environmental Policy Act Guidance on Consideration of Greenhouse Gas Emissions and Climate Change" with immediate effect, and the public comment period ended on April 10, 2023 (88 FR 10097). This GHG and climate change analysis for the US 51 North Study follows CEQ interim guidance recommendations and addresses NEPA requirements to assess project effects on the environment.

3.2. State

Wisconsin has been active in addressing GHG emissions and climate change. EO 38 was signed on August 16, 2019, and established the Office of Sustainability and Clean Energy. The Office of Sustainability and Clean Energy is charged with promoting the development and use of clean and renewable energy across the state, advancing innovative sustainability solutions that improve the state's economy and environment, and diversifying the resources used to meet the state's energy needs. The goal is to ensure that all electricity consumed within the State of Wisconsin is 100% carbon-free by 2050. As directed by EO 38, Wisconsin's first Clean Energy Plan was released in 2022.[10]

On October 17, 2019, Governor Tony Evers, along with Lieutenant Governor Mandela Barnes, signed EO 52, establishing the Governor's Task Force on Climate Change (Task Force). The Task Force advises and assists the governor in developing a strategy to mitigate and adapt to the effects of climate change for the benefit of all Wisconsin communities. The Task Force published the Governor's Task Force on Climate Change Report.[11] Several policy recommendations in the report are relevant to the transportation sector. The strategy includes recommending WisDOT to perform climate and environmental justice impact analyses as transportation-related projects are considered and developed. Climate and environmental justice impact analyses are part of the US 51 North Study.

Following this strategy, the study team analyzed the carbon emissions and environmental justice impacts associated with the study corridor. The carbon and climate impact analysis included an evaluation of the Study's potential impacts on vehicle miles traveled (VMT), transportation-related carbon emissions and an assessment of climate resilience.

EO 52 also directed the Wisconsin Initiative on Climate Change Impacts (WICCI) to collect and update scientific data on the rate of climate change in Wisconsin and its impact on Wisconsin's natural environment. Following the requirements in EO 52, WICCI released the Wisconsin's Changing Climate: Impacts and Solutions for a Warmer Climate – 2021 Assessment Report to share information that could foster solutions to climate change in Wisconsin.[12]

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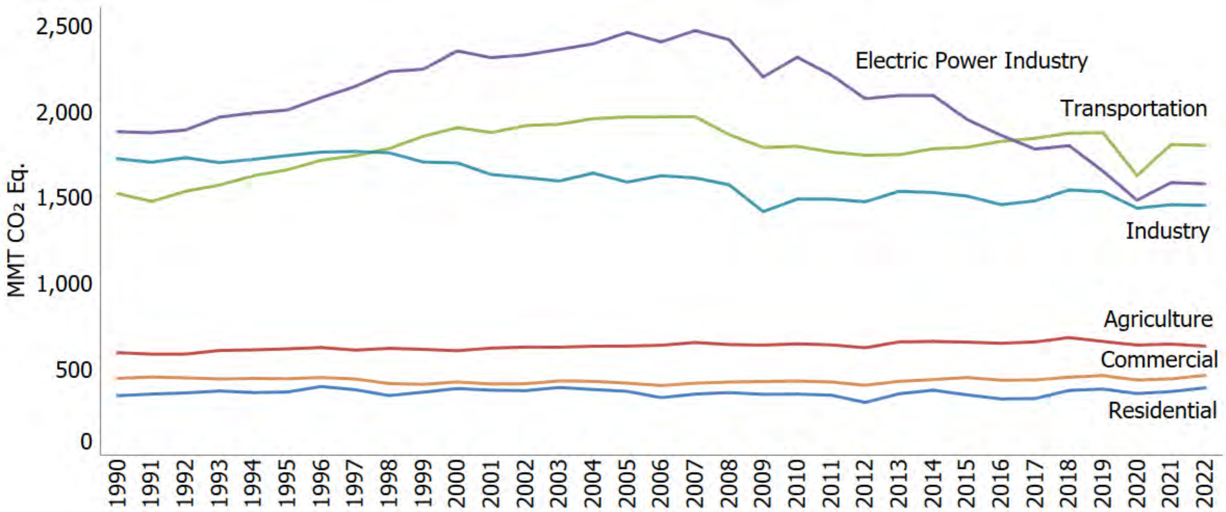
[10] *Wisconsin Office of Sustainability and Clean Energy. 2022. State of Wisconsin Clean Energy Plan. https://osce.wi.gov/Documents/SOW-CleanEnergyPlan2022.pdf. Accessed 30 May 2024.*

[11] *State of Wisconsin. 2020. Governor's Task Force on Climate Change Report. Madison, WI. https://climatechange.wi.gov/Documents/Final%20Report/GovernorsTaskForceonClimateChangeReport-LowRes.pdf. Accessed 30 May 2024.*

[12] *Wisconsin Initiative on Climate Change Impacts (WICCI). 2021. Wisconsin's Changing Climate: Impacts and Solutions for a Warmer Climate. https://uwmadison.app.box.com/s/lob4igia3b55u1q6kead7l91p14odoqu. Accessed 30 May 2024.*

decreased by 4.5%. U.S. GHG emissions were partly offset by carbon sequestration in managed forests, trees in urban areas, agricultural soils, landfilled yard trimmings and coastal wetlands. These were estimated to offset 14.5% of total gross emissions in 2022.

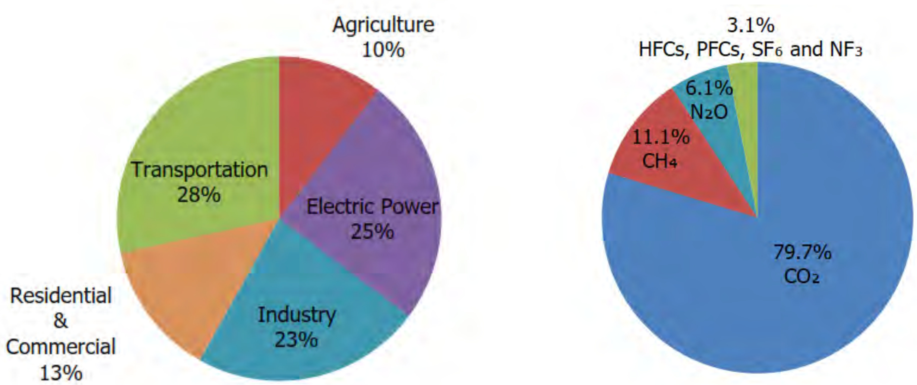
Figure 4-1: U.S. GHG Emissions 1990 to 2022 by Sector



Source: EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2022.[13]

The five major fuel-consuming economic sectors are transportation, electric power, industrial, residential and commercial. As shown in Figure 4-2, transportation activities accounted for the largest portion (28%) of total U.S. GHG emissions in 2022. Emissions from electric power accounted for the second largest portion (25%), while emissions from industry accounted for the third-largest portion (23%) of total U.S. GHG emissions in 2022. Of the total U.S. GHG emissions, 79.7% were CO_2. Combustion of fossil fuels for transportation and power generation is the largest source of CO_2 and of overall GHG emissions. In the transportation sector, CO_2 emissions have increased by 19.4% from 1990 to 2022. This rise in CO_2 emissions, combined with an increase in hydroflorocarbons from close to zero emissions in 1990 to 29.6 MMT CO_2e in 2022, led to an increase in overall GHG emissions from transportation activities of 18.6%.[13]

Figure 4-2: U.S. GHG Emissions in 2022

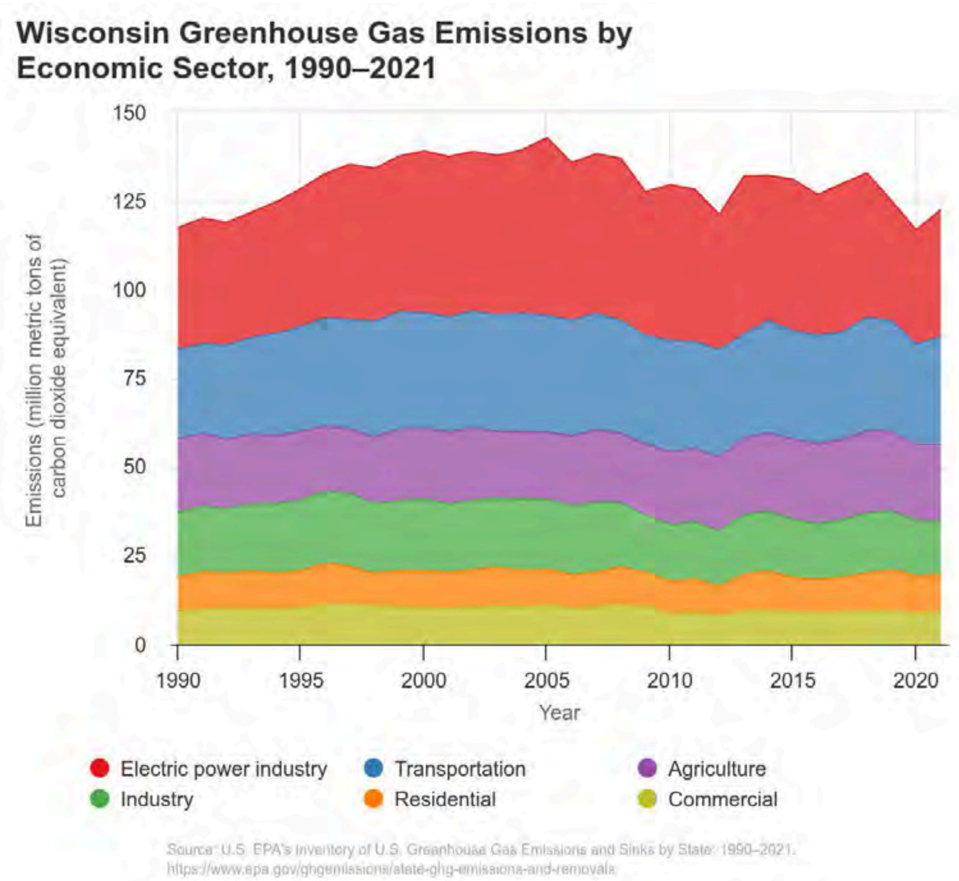


Source: EPA Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990–2022.[13]

4.2.2. State Greenhouse Gas Inventory

Wisconsin's gross GHG emissions[16] were 122.5 MMT CO_2e in 2021.[17] Electricity generation is the top contributor to the GHG emissions in Wisconsin (29.1%), followed by transportation (24.9%). Figure 4-3 shows Wisconsin's GHG emissions by sector during 1990 to 2021. The state's gross GHG emissions decreased by 4.3% between 1990 and 2021. The electricity emissions as a share of total emissions peaked in 2005, representing 38% of total emissions in 2005 and decreased to 29.1% of total emissions in 2021. Emissions from the transportation sector increased the most since 1990, representing 21.4% of total emissions in 1990 and 24.9% of total emissions by 2021.

Figure 4-3: Wisconsin GHG Emissions by Sector (1990-2021)



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[16] *Emissions are reported as both 'net' and 'gross' in the GHG inventory. Gross emissions include emissions from nine economic sectors: electricity, residential, commercial, industrial, transportation, industrial process, natural gas and oil, waste and agriculture. Net emissions are calculated by subtracting the annual carbon storage from the land-use, land-use-change and forestry sector from the total gross emissions.*

[17] *United States Environmental Protection Agency (EPA). 2024. Greenhouse Gas Emissions Inventory Data Explore. https://cfpub.epa.gov/ghgdata/inventoryexplorer/#allsectors/allsectors/allgas/select/all. Accessed 30 May 2024.*

4.3. Regional Plans

4.3.1. State and Regional

The Capital Area Regional Planning Commission (CARPC) is one of nine commissions in Wisconsin established to coordinate planning and development among area municipalities. CARPC develops and promotes regional plans, provides objective information, and supports local planning efforts. CARPC's planning region includes Dane County and the cities, towns, and villages with incorporated areas. In 2022, the CARPC adopted the 2050 Regional Development Framework as the region's advisory land use guide that established goals, objectives and strategies for accommodating future growth in the Dane County region.[18] The strategies outlined in the Framework promotes growth that reduces greenhouse gas emissions and fosters community resilience to climate change.

The Greater Madison Metropolitan Planning Organization is the federally designated Metropolitan Planning Organization (MPO) for the Madison area. The Greater Madison MPO and the CARPC collaborated on the Connect Greater Madison Regional Transportation Plan for 2050 that guides future transportation policy and investments for the region.[19] The Connect Greater Madison 2050 Regional Transportation Plan includes strategies to take action on critical issues, including equity and climate change. The plan established an environmental sustainability goal to minimize transportation-related greenhouse gas emissions that contribute to global climate change and design and maintain a transportation system that is resilient in the face of climate change.

WisDOT has adopted *Connect 2050* as Wisconsin's roadmap for transportation policy making.[20] The goal in *Connect 2050* is to maximize transportation system resiliency and reliability through (1) developing physical and operational systems that are adept at preventing, preparing for, and coordinating responses to any incident, whether natural or the result of human activity, (2) emphasizing system resiliency to reduce repair costs and improve safety and security, and (3) identifying and assessing risk-based solutions for system vulnerabilities.

4.3.2. Local

In 2020, Dane County published the 2020 Dane County Climate Action Plan: Today's Opportunity for a Better Tomorrow (CAP).[21] The CAP sets forth an ambitious set of climate goals for Dane County and lays out programs, policies, and projects that will enable the County to meet those goals. The goal established in the CAP is to reduce GHG emissions 50% county-wide by 2030 and put the county on a path to be carbon-neutral by 2050.

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[18] Capital Area Regional Planning Commission (CARPC). 2022. 2050 Regional Development Framework. https://www.capitalarearpc.org/wp-content/uploads/2024/01/RDF_Final-Report_July-2022.pdf Accessed 30 May 2024.

[19] Greater Madison Metropolitan Planning Organization. 2022. Connect Greater Madison 2050 Regional Transportation Plan for the Madison Metropolitan Area. https://www.greatermadisonmpo.org/planning/RegionalTransportationPlan2050.cfm. Accessed 30 May 2024.

[20] Wisconsin Department of Transportation (WisDOT). 2022. Connect 2050. https://drive.google.com/file/d/1F7Nhg-9EAnhtjrSIIsYhhiN4ylUqQcdF/view. Accessed 30 May 2024.

[21] Dane County. 2020. 2020 Dane County Climate Action Plan: Today's Opportunity for a Better Tomorrow. https://daneclimateaction.org/documents/CAP-2020/Dane-Co-Climate-Action-Plan-202004-web.pdf. Accessed 30 May 2024.

5.0 GHG Emissions and Effects

Transportation projects may contribute to climate change due to the GHG emissions from construction and operation of the transportation system. The primary GHGs produced by the transportation sector are CO_2, CH_4, and N_2O. CO_2 emissions are a product of gasoline or diesel fuel combustion in internal combustion engines, along with relatively small amounts of CH_4 and N_2O. Vehicles with internal combustion engines are a significant source of GHG emissions in the transportation sector and contribute to global climate change, as discussed in Section 4.2.

5.1. GHG Emissions

Lifecycle GHG emissions associated with the study corridor construction and operation were quantified as a proxy to evaluate the GHG impacts to the environment, as discussed in the following subsections. This section provides a summary of the GHG emission analysis approach and the results.

5.1.1. Analysis Years and Study Area

It is anticipated that construction of the study corridor would start in 2028 and finish in 2033. Construction will be carried out in phases with completed sections open to traffic starting in 2030. FHWA's Infrastructure Carbon Estimator (ICE), Version 2.2.8[22] has been modeled with construction year 2028, open year 2030 and design year 2050 to estimate emissions. Given the construction start year of 2028 used in ICE, emissions generated during 2028 and 2029 are included in the emission analysis. The analysis years to present the GHG emissions in this report are the opening year 2030 and the design year 2050. The analysis evaluated the annualized and cumulative emissions of construction and operation over 21 years between 2030 and 2050.

Descriptions of the preferred alternative is provided in Section 2.0.

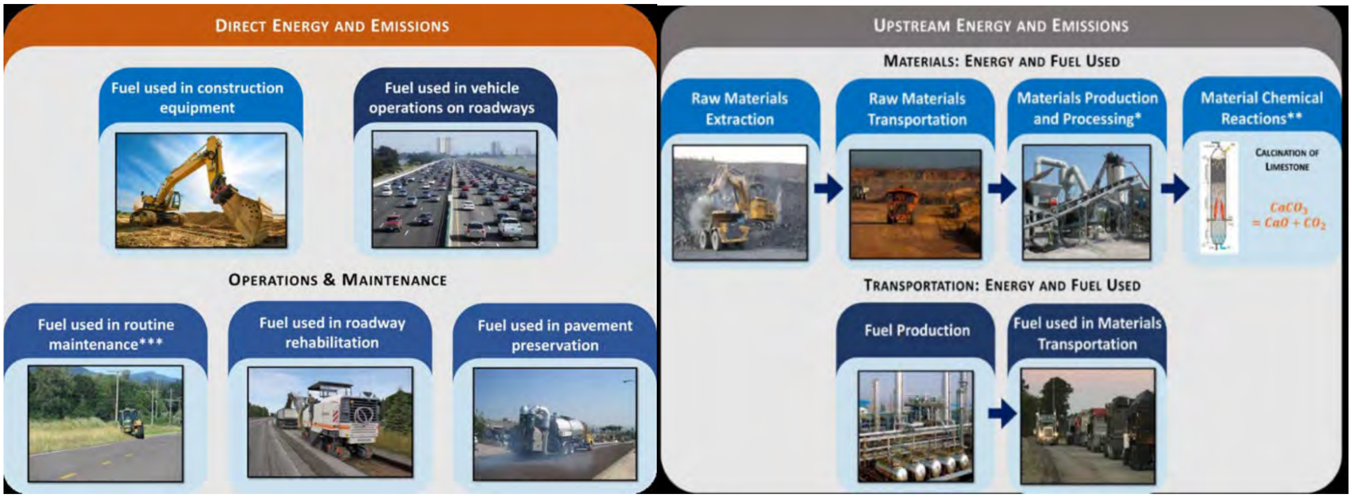
5.1.2. Emissions Associated with Construction Activities, Existing Roadway Maintenance & Vehicle Operations

GHG emissions from the study corridor associated with new construction activities, existing roadway maintenance and vehicle operations were estimated using ICE 2.2.8 with construction year 2028, open year 2030 and design year 2050. ICE 2.2.8 was developed by FHWA to estimate the lifecycle energy and GHG emissions from transportation infrastructure construction, maintenance and operation. Lifecycle GHG accounting evaluates and reports the GHG emissions associated with the raw materials extraction, manufacturing or processing, transportation, use and end-of-life management of a good or service.

ICE 2.2.8 considers the direct and indirect (upstream) emissions to estimate construction-, operation- and maintenance-related emissions as shown in Figure 5-1 below.

[22] *Federal Highway Administration (FHWA). 2023. Infrastructure Carbon Estimator (ICE), Version 2.2.8.*

Figure 5-1: GHG Emissions Sources Evaluated in ICE 2.2.8



Source: ICE Version 2.2.8.23

Notes:
** For example, crushing of aggregate, asphalt batch plants*
*** For example, CO2 emitted from calcination of limestone*
**** Activities include sweeping, striping, bridge deck repair, litter pickup and maintenance of appurtenances*

GHG emissions from the study area were modeled using ICE 2.2.8 and broken into five categories:

- **Material**: Includes the upstream emissions associated with construction materials extraction, production, chemical reaction and raw material transportation.
- **Transportation**: Includes upstream emissions associated with fuel used in transportation of materials to the site.
- **Construction**: Includes the emissions from energy and fuel used in construction equipment.
- **Operations & Maintenance (O&M)**: Includes the emissions from routine maintenance of the infrastructure, such as snow removal and vegetation management, roadway repair and rehabilitation and other routine maintenance.
- **Usage**: Includes emissions from vehicle travel on roadways.

Construction and Maintenance Emissions

Study corridor construction is anticipated to start in 2028 and to last approximately 5 years. Sections on the study corridor will open as construction is completed. Therefore, some of the sections may start operation as early as 2030. GHG construction and maintenance emissions from the Build alternatives were modeled using ICE 2.2.8 based on the construction information of each alternative and design options, and including the emissions from the following infrastructure and activities from construction year 2028 to design year 2050:

- Roadways
- Culverts

[23] Federal Highway Administration (FHWA). 2022. "National Performance Management Measures; Assessing Performance of the National Highway System, Greenhouse Gas Emissions Measure." Federal Register. Vol. 87, No. 135. July 15.

- Roadway Reconstruction
- Pathways

For the No Build alternative, only the emissions from existing roadway's O&M were estimated using ICE 2.2.8. There would be no construction activities under the No Build alternative.

Direct tailpipe GHG emissions during the construction phase due to vehicle traffic delay were modeled using ICE 2.2.8 model. GHG emissions were modeled based on the impacted VMT and congested speed information from the travel demand model for the project corridor. ICE 2.2.8 calculation sheets and the emission summary are in Appendix A.

Long-term Vehicle Operation Emissions

Vehicle operation emissions were estimated for a 21-year period from 2030 and 2050 for both No Build and Build alternatives. Emissions associated with vehicle operations on roadway in 2030 and 2050 were modeled using ICE 2.2.8 based on the anticipated VMT and speed information. This information was collected from the Dane County Travel Demand Model for the study corridor and associated intersections segments.

Emissions Summary

ICE 2.2.8 generates the total construction and operation emissions over a project's lifetime and annualizes the cumulative emissions by dividing the cumulative emissions by the time period. The time frame of the GHG emission analysis was based on a 21-year lifetime (from open year 2030 to design year 2050) to be conservative, although the typical lifetime of a transportation project is anticipated to be 50 to 75 years. The lifecycle GHG emissions are presented in the unit of metric tons of carbon dioxide equivalent (MT CO_2e), which are calculated as the product of the mass of a given GHG and its specific GWP. Annualized lifecycle GHG emissions from the study corridor's construction, O&M and vehicle operation are summarized in Table 5-1.

Table 5-1: Annualized Lifecycle GHG Emissions from Construction, O&M, and Vehicle Operation (MT CO_2e/year)

Activities	No Build	Build
Roadways (Materials, Transportation, Construction and O&M)	275	654
Roadway Reconstruction (Materials, Transportation, Construction)	-	294
Culverts (Materials, Transportation, Construction)	-	48
Pathways (Materials, Transportation, Construction and O&M)	-	7
Vehicle Operations - Construction Delay	-	340
Vehicle Operations - VMT Operations	23,470	23,470
Total Construction, O&M, and Vehicle Operation	23,746	24,813
Difference Build vs No Build	NA	1,067
Difference Build vs No Build %	NA	4.5%

Source: FHWA ICE tool, Version 2.2.8

As shown in Table 5-1, the greatest GHG emissions would be from vehicle operation (vehicle travel) on the study corridor. However, annualized GHG emissions from the Build and No Build alternatives would be similar. The annualized GHG emissions of the Build alternatives would be 4.5% higher than the No Build alternative due to intersection and corridor construction activities.

There would be no construction emissions from the No Build Alternative. O&M emissions from the No Build alternative were estimated using ICE 2.2.8 and includes the emissions from O&M of the roadways. Due to the age of the existing roadway, the deteriorated roadway conditions and the associated higher maintenance needs under the No Build alternative would likely require more O&M activities. Because ICE 2.2.8 does not consider the age of the roadways when estimating the O&M emissions, O&M emissions from the No Build alternative would likely be higher than what is presented in Table 5-1.

5.1.3. Cumulative GHG Emissions

Cumulative GHG emissions are the total emissions from the study corridor construction and operation over the 21-year analysis period in the study area. Cumulative GHG emissions from the No Build and Build alternatives were modeled by ICE 2.2.8 and summarized in Table 5-2. Emission trends between the No Build and Build alternatives are consistent with the trends of the annualized emissions that the cumulative GHG emissions from the Build alternatives would be 4.5% higher than the No Build alternative.

Table 5-2: Cumulative GHG Emissions (Construction and Operation in 2030-2050), MT CO_2e

Activities	No Build	**Build**
Roadways (Materials, Transportation, Construction and O&M)	5,779	13,735
Roadway Reconstruction (Materials, Transportation and Construction)	-	6,171
Culverts (Materials, Transportation, Construction)	-	999
Pathways (Materials, Transportation, Construction and O&M)	-	156
Vehicle Operations - Construction Delay	-	7,133
Vehicle Operations - VMT Operations	492,877	492,877
Total Construction, O&M, and Vehicle Operation	498,656	521,071
Difference Build vs No Build	NA	22,415
Difference Build vs No Build %	NA	4.5%

Source: FHWA ICE tool, Version 2.2.8

The Dane County Climate Action Plan has set a goal to reduce GHG emissions by 50% relative to 2020 levels by 2030, although it did not state specific emissions levels. The city of Madison's Inventory of Community-wide Greenhouse Gas Emissions[24] includes observed GHG emissions for the years 2018 and 2022. These values were interpolated to estimate the emission for 2020, and the 2030 emission target was calculated based on this estimation.

If the city of Madison adopted Dane County's 50% reduction target by 2030, the target level of GHG emissions in 2030 would be 2.13 million metric tons (MMT) of CO2e, with a target of 0.60 MMT CO2e specifically for transportation & mobile sources. Based on the emissions calculated for the project corridor using ICE 2.2.8, the No Build alternative is projected to produce emissions that are 1.12% of the 2030 overall emission target and 3.98% of the transportation & mobile sources target. This increases slightly for the Build alternative, with emissions projected to be 1.17% of the 2030 overall emission target and 4.16% of the transportation & mobile sources target. Project emissions, relative to Dane County's 50% reduction target, are provided in Table 5-3.

[24] *City of Madison. 2024. 2018 & 2022 Inventory of Community-wide Greenhouse Gas Emissions.https://www.cityofmadison.com/sustainability/documents/Madison%2020182022%20Community-Wide%20Greenhouse%20Gas%20Emissions_Final%20%28reduced%29.pdf Accessed 8 August 2024.*

Table 5-3: Contextualization of Project Emissions Relative to Potential 50% Reduction Target by 2030

Year	Overall			Transportation & Mobile Sources		
	City of Madison CO2e Potential Target (MMT)	CO2e ratio between Alternatives and Target		City of Madison CO2e Potential Target (MMT)	CO2e ratio between Alternatives and Target	
		No Build	Build		No Build	Build
2020	4.25	-	-	1.19	-	-
*2022	4.08	-	-	1.14	-	-
2030	2.13	1.12%	1.17%	0.60	3.98%	4.16%

Source: WisDOT, 2024

**2022 Emission is observed value*

5.1.4. GHG Equivalency

CEQ interim guidance indicates that agencies may provide accessible comparisons or equivalents for the public and decision makers to understand GHG emissions in more familiar terms, such as placing GHG emissions as household emissions per year, average emissions from a certain number of cars on road, or amount of fuel burned. Based on the GHG emission results, GHG equivalency values were derived using EPA's Greenhouse Gas Equivalencies Calculator and are summarized in Table 5-4.[25]

Table 5-4: Annualized GHG Emissions Equivalency for the Emissions Increases from Build Alternatives (Compared to No Build Alternative)

	GHG Equivalency (Emission Increase of Build Alternatives)
Barrels of crude oil consumed per year	2,470
Gasoline-powered passenger vehicles driven for one year	254
Tanker truck's worth of gasoline per year	14.1
Natural-gas-fired power plant in one year	0.003

Source: WisDOT, 2024

5.2. Social Cost of GHG Emissions

Following the CEQ interim guidance, to provide additional context for GHG emissions, social costs of GHG (SC-GHG) due to GHG emissions from the Study alternatives were estimated to translate climate impacts into the more accessible metric of dollars, to allow decision makers and the public to make comparisons, help evaluate the significance of an action's climate change effects and better understand the tradeoffs associated with an action and its alternatives.

The SC-GHG is a measure, in dollars, of the long-term damage done by a ton of GHG emissions in a given year. This dollar figure also represents the value of damages avoided for a small emission reduction (i.e., the benefit of a GHG reduction). The SC-GHG is meant to be a comprehensive estimate of climate change damages and includes

[25] *United States Environmental Protection Agency (EPA). 2023. Greenhouse Gas Equivalencies Calculator. https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator. Accessed 30 July 2024.*

changes in net agricultural productivity, human health, property damages from increased flood risk and changes in energy system costs, such as reduced costs for heating and increased costs for air conditioning. The models used to develop SC-GHG estimates, known as integrated assessment models, do not currently include all of the important physical, ecological, and economic impacts of climate change recognized in the climate change literature because of a lack of precise information on the nature of damages and because the science incorporated into these models naturally lags behind the most recent research. Nonetheless, the current estimates of the SC-GHG are a useful measure to assess the climate impacts of CO_2 emission changes.[26]

EO 13990 re-established the Interagency Working Group (IWG) on the Social Cost of Greenhouse Gases and directed it to ensure that SC-GHG estimates used by the U.S. government reflect the best available science and the recommendations of the National Academies and work toward approaches that take account of climate risk, environmental justice and intergenerational equity.[27] EPA is a member of the IWG and is participating in the IWG's work under EO 13990. The SC-GHG values used in this analysis are from EPA's *Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review" EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances*[21]

5.2.1. Social Cost Estimate Methodology

GHG emissions from the study corridor construction and operation were estimated using the FHWA's ICE tool, and the output results are presented as CO_2e. Unit SC-GHG cost factors vary for each type of the GHG; however, emissions of different types of GHG of CO_2, CH_4 and N_2O are not provided in ICE 2.2.8 outputs, which is a limitation of the model. Because a majority of the GHG emissions from the construction and operation would be CO_2 from fuel combustion and the GHG emissions are expressed as CO_2e, it was assumed that the CO_2e emissions are 100% CO_2 in the SC-GHG calculations. SC-GHG for emissions from the opening year in 2030 and design year 2050 were calculated to provide information of the SC-GHG on an annual basis. Cumulative SC-GHG associated with the GHG emissions in the 21-year analysis period from 2030 to 2050 were calculated for the No Build and Build alternatives. Unit social costs for CO_2 were taken from the EPA SC-CO_2 Technical Support Document and are presented by emission year in 2020 dollars per MT CO_2e at various discount rates.[28]

The SC-GHG discount rates are important factors influencing SC-CO_2 estimates. A large portion of climate change damages are expected to occur many decades into the future, and the present value of those damages (the value at present of damages that occur in the future) is highly dependent on the discount rate. Future costs and benefits are considered less than present costs and benefits, and the discount rate reflects this level of relative significance. A high discount rate means that future effects are considered much less significant than present effects, whereas a low discount rate means that they are closer to equally significant. The SC-GHG analysis evaluated all three discount rates in EPA's report (2.5%, 2.0%, and 1.5%), to present the potential ranges of the SC-GHG of the alternatives.

Because the unit SC-GHG cost factors vary by the year the emissions would occur, SC-GHG from the Build and No Build alternatives were calculated on a year-by-year basis. Year-by-year GHG emissions between 2030 and 2050 were calculated from annualized GHG values that were obtained from ICE 2.2.8 outputs. Annual SC-GHG between 2030 to 2050 was calculated by multiplying the unit SC-CO_2 cost factors (in 2020 dollars per MT of each respective GHG) by the corresponding GHG emissions for each year. The cumulative SC-GHG were calculated by summing the annual SC-GHG during 2030 to 2050.

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[26] *United States Environmental Protection Agency (EPA). 2023. Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review" EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances. https://www.epa.gov/system/files/documents/2023-12/epa_scghg_2023_report_final.pdf. Accessed 30 May 2024.*

[27] *Interagency Working Group on Social Cost of Greenhouse Gases (IWG). 2021. Technical Support Document: Social Cost of Carbon, Methane, and Nitrous Oxide. February. https://www.whitehouse.gov/wp-content/uploads/2021/02/TechnicalSupportDocument_SocialCostofCarbon MethaneNitrousOxide.pdf. Accessed 30 May 2024.*

[28] *EPA (2023), supra note 26 on page 5-6*

5.2.2. Annual Social Cost of GHG Emissions

Annual SC-GHG were calculated for the years 2030 and 2050. The annual emissions used in the SC-GHG calculation included the vehicle operation emissions based on the operational VMT in the study area in 2030 and 2050, and the annualized construction emissions. Because unit SC-GHG cost factors are dependent on the year that the emissions would occur, the 21-year annualized emissions from ICE 2.2.8, as presented in Table 5-1, were used in the annual SC-GHG calculation. SC-GHG values resulting from the No Build and the Build alternatives in 2030 and 2050 are summarized in Table 5-5.

For the same emission year and discount rate, the SC-GHG of the Build alternatives would be 4.5% higher than the No Build alternatives for the 2030 emission year, and 4.5% higher than the No Build alternative for the 2050 emission year. SC-GHG would be higher in 2050 than in 2030, which is consistent with the trend of the higher GHG emissions and the higher unit SC-GHG cost factors.

Table 5-5: Social Cost of Greenhouse Gases for Emissions in 2030 and 2050 (in 2020 dollars) and Comparisons to No Build Alternative

	2030				**2050**			
Discount Rate	**No Build**	**Build**	**Change (Build vs No Build)**	**% Change (Build vs No Build)**	**No Build**	**Build**	**Change (Build vs No Build)**	**% Change (Build vs No Build)**
2.5%	$3,419,355	$3,573,058	$153,703	4.50%	$4,867,832	$5,086,645	$218,813	4.50%
2.0%	$5,461,470	$5,706,968	$245,498	4.50%	$7,313,621	$7,642,375	$328,753	4.50%
1.5%	$9,118,281	$9,528,155	$409,874	4.50%	$11,445,342	$11,959,820	$514,478	4.50%

Source: WisDOT, 2024.

5.2.3. Cumulative Social Cost

Cumulative SC-GHGs during the 21-year analysis period were estimated for the No Build and Build Alternatives as described in Section 5.2.1. The cumulative SC-GHGs of the study corridor are summarized in Table 5-6. The cumulative SC-GHG of the Build alternatives would be approximately 4.5% higher than the cumulative SC-GHG of the No Build alternative.

Table 5-6: Cumulative Social Cost in 2030 to 2050 (in 2020 dollars) and Comparisons to No Build Alternative

	SC-GHG ($) 2030-2050			
Discount Rate (%)	No Build	Build Alternatives	Changes (Build vs No Build)	Percent Changes (Build vs No Build)
2.5%	$86,599,925	$90,492,664	$3,892,738	4.50%
2.0%	$133,592,317	$139,597,402	$6,005,085	4.50%
1.5%	$215,466,883	$225,152,298	$9,685,415	4.50%

Source: WisDOT, 2024

5.2.4. Environmental Justice

Demographic analysis of the study corridor revealed both minority and low-income populations reside within the vicinity of the study area. The complete environmental justice analysis will be provided in Sections 12 and 14 of the Environmental Assessment Template and the Environmental Justice Factor sheet in the Study's EA.

Preliminary analysis shows the total minority population residing within 0.5-mile of the study area to represent about 35 percent of the total population, refer to Table 5-7. Of the total minority population, Black and African American (13.2%) are the largest single minority population, followed by Hispanic (12.4%), Two or More Races (5.2%) and Asian (3.6%). These minority populations generally reside throughout the entire corridor. Nearest the Dane County Regional Airport and the US 51 and WIS 30 interchange, minority populations make up a greater proportion of the total population and surpass the Dane County average minority population rate of 21.8%.[29]

The study team analyzed median household income level and the rate of poverty to directly account for low-income populations within 0.5-mile of the study area. The median household income within 0.5-mile of the study area, as of 2021, was $61,185. This is lower than the median household income for Dane County ($77,221) and for the state of Wisconsin ($67,125).[30] Median incomes nearest the Dane County Regional Airport were below $35,000 and generally less than $60,000 near the US 51 and WIS 30 interchange. Poverty data from the U.S. Census Bureau American Community Survey (2017-2021) indicates about 12.5% of persons residing within 0.5-mile of the study area live below the poverty threshold. Poverty data also indicated higher rates of poverty (greater than 20%) near the Dane County Regional Airport and the US 51 and WIS 30 interchange.

Table 5-7: Population Demographics, Race and Ethnicity

	Study Boundary		0.25-Mile Boundary		0.5-Mile Boundary		Dane County		State of Wisconsin	
	Count	%	Count	%	Count	%	Count	%	Count	%
Population	2,684	100.0%	8,743	100.0%	15,454	100.0%	555,474	100.0%	5,871,661	100.0%
White	1,766	65.8%	5,621	64.3%	10,096	65.3%	434,318	78.2%	4,705,965	80.1%
Minority	918	34.2%	3,122	35.7%	5,357	34.7%	121,156	21.8%	1,165,696	19.9%
African American	350	13.0%	1,260	14.4%	2,047	13.2%	27,528	5.0%	364,446	6.2%
American Indian	1	0.0%	7	0.1%	22	0.1%	1138	0.2%	39,457	0.7%
Asian	83	3.1%	263	3.0%	561	3.6%	33,102	6.0%	165,139	2.8%
Native Hawaiian Pacific Islander	1	0.0%	4	0.0%	6	0.0%	193	0.0%	2,395	0.0%
Other	0	0.0%	1	0.0%	5	0.0%	1,789	0.3%	12,531	0.2%
Two or More	175	6.5%	494	5.7%	801	5.2%	20,244	3.6%	157,130	2.7%
Hispanic	308	11.5%	1,093	12.5%	1,915	12.4%	37,165	6.7%	424,598	7.2%

Source: U.S. Census Bureau. American Community Survey, 2017-2021 5-Year Data

[29] *U.S. Census Bureau. American Community Survey, 2017-2021 5-Year Data.*
[30] *Ibid.*

5.3. Mitigation for Greenhouse Gas Emissions

Reducing GHG emissions is a key strategy to address climate change impacts. GHG emissions would be produced at different levels throughout the study corridor's construction phase. At a project level, although GHG mitigation measures are not specifically required under NEPA or other state and federal regulations, WisDOT will follow its Standard Specifications that exist to address pollution reduction/containment measures for the contractor, and also implement the following mitigation measures to help reduce GHG emissions, as appropriate to the size and scale of each construction project:

- Implement strategic construction timing where feasible to reduce construction delays, including vehicle idling from backups.
- Set up active construction zones, staging areas and material transfer sites in a way that reduces standing wait times for equipment. Reducing idling times reduces GHG emissions from passenger cars and construction vehicles.
- Work with contractors and subcontractors to reduce idling times.
- Communicate with local municipalities and neighborhood groups, including groups focused on serving environmental justice populations, as to the location of staging areas and material transfer sites. Work with the same municipalities and groups to minimize the impacts of staging areas and material transfer sites.
- Encourage construction contractors to use ridesharing and other commute trip reduction efforts to reduce GHG emissions from commute vehicles of employees working on the project.
- WisDOT will post signs to encourage construction staff to use public transport or rideshare.
- Implement traffic demand management, and transportation systems management and operations planning measures into plans and construction staging, including freeway monitoring and advisory information, crash investigation sites and law enforcement pads, traffic detectors and enhanced mile-marker posts.
- Encourage contractors to recycle construction and demolition materials to the extent possible. Asphalt, concrete and rubble are often recycled into aggregate or new asphalt and concrete products. Metals—including steel—are also valuable commodities to recycle.
- Use LED bulbs in new lighting installed along the study corridor. LEDs use less electricity than traditional light bulbs, which in turn reduces the amount of fuel being burned to generate electricity.
- Construction of the study corridor will follow WisDOT project site air quality specifications. This includes voluntarily establishing staging zones for trucks waiting to load and unload; locating staging zones where idling of diesel-powered equipment will have minimal impact on abutting properties and the general public; having trucks queue up in these zones when practicable; and encouraging drivers to shut down diesel trucks as soon as it appears likely they will be queued up for more than 10 minutes.
- Public vehicle access to and from the study corridor during construction would be maintained to the extent possible, or alternative access would be provided. If alternative access is not available, the specific construction activity would be reviewed to determine if it could occur during non-peak hours.
- WisDOT will continue to coordinate with the city of Madison and Madison Metro Transit throughout design and construction to support transit service implementation and avoid and minimize transit service disruption during construction.
- Additional bicycle and pedestrian facilities, which are part of the Build alternatives, support alternative transportation choices.

The Study's preferred alternative includes installation of bicycle and pedestrian facilities that do not exist in the existing condition. Construction of these facilities will enable individuals to make alternative transportation.

Mitigation measures have been identified to minimize construction impacts (including GHG impacts) on environmental justice populations. Prior to construction, a plan would be developed to establish construction phases, estimated durations, appropriate sequencing, and community outreach and communication commitments. WisDOT would continue its targeted stakeholder outreach inclusive of minority and low-income populations. Access to and from the Interstate during construction would be maintained to the extent possible, or alternative access would be provided. If alternative access is not available, the specific construction activity would be reviewed to determine whether it could occur during non-peak hours.

The mitigation measures described previously are part of the effort by FHWA to adopt practicable means to avoid and minimize environmental harm in accordance with 40 Code of Federal Regulations 1505.2 and will be further developed during final design. These collective measures would reduce or offset GHG emissions from study corridor construction and benefit all populations, including environmental justice populations, living along the study corridor.

6.0 Effects of Climate Change

Climate change effects experienced at local and regional levels are not the direct result of an individual project's GHG contributions, but the result of cumulative, global GHG contributions. Reducing GHG emissions is only one part of an approach to addressing the effects of climate change. WisDOT is also addressing effects of climate change on the state's transportation infrastructure and working to strengthen and protect the transportation infrastructure from damage from climate change.[20]

Globally, climate change is expected to produce increased variability in precipitation, rising temperatures, rising sea levels, variability in storm surges and their intensity and in the frequency and intensity of wildfires. Flooding and erosion can damage or wash out roads, longer periods of intense heat can buckle pavement and railroad tracks and storm surges combined with rising sea levels can inundate highways. Wildfire can directly burn facilities and indirectly cause damage when rain falls on denuded slopes that landslide after a fire. Effects will vary by location and may, in the most extreme cases, require that a roadway be relocated or redesigned.

Wisconsin is expected to experience higher temperatures, increased precipitation and more extreme weather events in future years, as further discussed in Section 6.1.3. Climate change also affects people's health in many ways. As the climate changes, more people may be exposed to extreme weather like heat, floods, droughts, storms and wildfires. These events can cause illness, injury and even death. Climate change can also lead to more diseases spread by insects and ticks, and it can affect the quality and safety of air, water and food, including through the spread of harmful bacteria or viruses. In addition, hazards related to climate change can affect mental health, such as causing anxiety, depression and post-traumatic stress.[31]

As noted in the CEQ interim guidance, most severe harms from climate change fall disproportionately upon underserved populations who are least able to prepare for and recover from heat waves, poor air quality, flooding, and other impacts. Racial and ethnic minority populations are particularly vulnerable to the greatest impacts of climate change per EPA.[32] As noted by USDOT, the effects of climate change often have a more detrimental effect on vulnerable populations and can disproportionately impact minorities and low-income populations.[33]

Minority and low-income populations reside within 0.25-mile and 0.5-mile of the study area to a similar extent. Within 0.5-mile of the study area minority populations comprise about 35% of the total population, while low-income populations comprise about 12.5% (refer to Table 5-7); however these populations are not evenly distributed throughout the study area. Minority and low-income populations both comprise over 40% of several US Census block groups in the southern half of the 0.5-mile study boundary; while north of the Dane County Regional Airport generally less than 10% of the population identifies as a minority and/or low-income population.[34] The resolution of the Study's environmental justice analysis is set by US Census Bureau block groups. Refer to the Study's

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[31] *United States Environmental Protection Agency (EPA). 2023. Climate Change Impacts on Health. https://www.epa.gov/climateimpacts/climate-change-impacts-health. Accessed 30 May 2024.*

[32] *United States Environmental Protection Agency (EPA). 2021. Climate Change and Social Vulnerability in the United States: A Focus on Six Impact Sectors. https://www.epa.gov/system/files/documents/2021-09/climate-vulnerability_september-2021_508.pdf. Accessed 30 May 2024.*

[33] *United States Department of Transportation (USDOT). 2023. https://www.transportation.gov/priorities/climate-and-sustainability/climate-action. Accessed 30 May 2024.*

[34] *WisDOT. 2024. US 51 North Study – Environmental Justice Plan and Preliminary Analysis.*

Environmental Justice Plan and Preliminary Analysis – Figure 5 through Figure 12 – for the locations of minority and low-income populations within the vicinity of the study area.

As the study would not add capacity to the US 51 study corridor, No Build and Build alternative VMT GHG emissions are equivalent. The Build alternative would generate construction related GHG emissions, resulting in 4.5% more cumulative GHG emissions as compared to the No Build alternative. Climate change is a global phenomenon and the impacts of a changing climate do not affect all populations equally. Environmental justice populations are typically exposed to a disproportionate amount of air pollution and other environmental hazards. While populations at the study corridor, local and regional levels may experience the effects of climate change, the effect is not the direct result of an individual project's contributions, but the result of cumulative, global GHG contributions.

The mitigation measures, outlined in Section 5.3, have been identified to minimize construction impacts, including GHG emissions, to environmental justice populations and the general population. For example, WisDOT plans to work with municipalities and stakeholders, including groups focused on serving environmental justice populations, to select locations for construction staging areas and material transfer sites that would minimize the impacts of GHG emissions from construction equipment to residential populations. By implementing the mitigation measures outlined in Section 5.3, construction generated GHG emissions would be reduced or offset, and the impacts of GHG emissions would be minimized to all populations, including environmental justice populations. While environmental justice populations would experience GHG impacts, the impacts are anticipated to be similar to the impacts experienced by the general population. Furthermore, environmental justice populations are not anticipated to experience disproportionate impacts due to GHG emissions along the study corridor.

Refer to section 12 of the Study's EA for the complete environmental justice analysis. WisDOT will continue to provide meaningful engagement opportunities for environmental justice populations throughout final design. Environmental justice populations will be able to express any concerns about GHG impacts, and WisDOT will work with them to develop appropriate construction mitigation. The Environmental Justice Factor Sheet, attached to the Study's EA, also describes the outreach and engagement opportunities afforded to environmental justice populations as part of this Study.

6.1. Present and Projected Future Climate Change Effects

6.1.1. National Level

According to the Fifth National Climate Assessment, global average temperatures over the past decade (2012–2021) were close to 2 degrees Fahrenheit [°F] (1.1 degrees Celsius [°C]) warmer than the preindustrial period (1850–1899). This warming has been accompanied by several large-scale changes: loss of glaciers, ice sheet mass and sea ice; ocean warming, acidification and deoxygenation; increases in ocean heat content and marine heatwaves; increases in atmospheric humidity; shifting rainfall patterns and more frequent heavy precipitation; seasonal shifts including shorter winters and earlier spring and summer seasons and changes in the biosphere. [36]

Temperatures in the contiguous United States have risen by 2.5°F and temperatures in Alaska by 4.2°F since 1970, compared to a global temperature rise of around 1.7°F over the same period. There are substantial seasonal and regional variations in temperature trends across the U.S. and its territories. Winter is warming nearly twice as fast as summer in many northern states. Annual average temperatures in some areas (including parts of the southwest, upper Midwest, Alaska, and northeast) are more than 2°F warmer than they were in the first half of the 20th century, while parts of the Southeast have warmed less than 1°F.

Many eastern regions of the country are getting wetter. Average annual precipitation from 2002–2021 was 5 to 15% higher relative to the 1901–1960 average in the central and eastern U.S. Parts of the southwest are getting drier, recording average annual precipitation decreases between 10 and 15% over the same time period. The timing of precipitation is also changing. While the northeast and Midwest have seen wetter conditions in all seasons, the southeast has received more precipitation in the fall but drier conditions in spring and summer. The Pacific Northwest also experienced drier summers and wetter winters.

Observations show an increase in the severity, extent and/or frequency of multiple types of extreme events. Heatwaves have become more common and severe in the west since the 1980s. Drought risk has been increasing in the southwest over the past century, while at the same time rainfall has become more extreme in recent decades, especially east of the Rockies. Hurricanes have been intensifying more rapidly since the 1980s and causing heavier rainfall and higher storm surges. More frequent and larger wildfires have been burning in the west in the past few decades.

The impacts of climate change increase with warming, and warming is virtually certain to continue if emissions of CO_2 do not reach net zero. Rapidly reducing emissions would very likely limit future warming and the associated increases in many risks. The Paris Agreement calls for limiting the global warming level[35] to well below 3.6°F (2°C) relative to preindustrial temperatures. At a global warming level of 3.6°F (2°C), the average temperature across the U.S. is very likely to increase between 4.4°F and 5.6°F (2.4°C and 3.1°C). For every additional 1°C of global warming, the average U.S. temperature is projected to increase by around 2.5°F (1.4°C). The northern and western parts of the country are likely to experience proportionally greater warming.[36]

Annual precipitation since the beginning of the last century has increased across most of the northern and eastern U.S. and decreased across much of the southern and western U.S. Over the coming century, significant increases are projected in winter and spring over the Northern Great Plains, the upper Midwest and the northeast. Observed increases in the frequency and intensity of heavy precipitation events in most parts of the U.S. are projected to continue. Surface soil moisture over most of the U.S. is likely to decrease, accompanied by large declines in snowpack in the western U.S. and shifts to more winter precipitation falling as rain rather than snow.[37] In the U.S., projected changes in seasonal mean precipitation span the range from profound decreases to profound increases.

6.1.2. Midwest

The Midwest National Climate Assessment region covers Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, Ohio and Wisconsin. The Fifth National Climate Assessment states key impacts to the Midwest region due to climate change as follows:[36]

- Climate change is expected to negatively impact individual and community health.
- Increasing extreme precipitation events and transitions between wet and dry conditions are expected to negatively impact agriculture.
- Increasing incidence of flooding and drought is expected to negatively affect the ecosystem.
- Increases in temperatures and extreme precipitation events are already challenging aging infrastructure and are expected to impair surface transportation, water navigation and the electrical grid.
- Shifts in the timing and intensity of rainfall are expected to disrupt transportation along major rivers and increase chronic flooding.

The Midwest is subject to extremely cold air masses from the far north, and warm, humid air masses from the Gulf of Mexico, resulting in a wide range of both temperature and precipitation extremes.[38] The Midwest has gotten warmer, with average annual temperatures increasing over the last several decades. The annual average temperature of the Midwest National Climate Assessment region for the mid-century period of 2036-2065 relative to

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[35] *The global warming level is defined as the global average temperature change in degrees Celsius relative to preindustrial temperatures.*

[36] *United States Global Change Research Program (USGCRP). 2023. Fifth National Climate Assessment. https://nca2023.globalchange.gov/. Accessed 30 May 2024.*

[37] *United States Global Change Research Program (USGCRP). 2018. Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II. https://nca2018.globalchange.gov/downloads/. Accessed 30 May 2024.*

[38] *National Oceanic and Atmospheric Administration (NOAA). 2013. Regional Climate Trends and Scenarios for the US National Climate Assessment. Part 3. Climate of the Midwest. NOAA Technical Report NESDIS 142-3. https://scenarios.globalchange.gov/sites/default/files/NOAA_NESDIS_Tech_Report_142-3-Climate_of_the_Midwest_U.S_0.pdf. Accessed 30 May 2024.*

1976-2005 is projected to rise 4.2°F for a lower scenario (RCP4.5) and 5.3°F for a higher scenario (RCP8.5).[39] Precipitation is greatest in the eastern part of the Midwest and less toward the west. Heavy downpours are already common, but climate change is expected to intensify storms and lead to greater precipitation across the entire region during this century.[38] Precipitation is projected to increase by about 10 to 20% during the winter and spring, increase by 0 to 10% during the fall, and decrease by 0 to 10% during the summer in the general Wisconsin area for 2070-2099 compared to 1976-2005.[39] Projected changes in cumulative local runoff are expected to lead to increased flooding susceptibility in the winter and spring and increased flash drought potential in the summer.[36]

More intense precipitation in the Midwest is expected to lead to increased flood damage, strained drainage systems and reduced drinking water availability.[38] Stormwater management systems, transportation networks and other critical infrastructure are already experiencing impacts from changing precipitation patterns and elevated flood risks.[37] Midwestern cities with impervious infrastructure may result in surface runoff entering combined storm and sewage drainage systems. When these systems are overloaded during intense rainstorms, raw sewage overflow can result, impacting clean water availability and human health.[38] The annual cost of adapting urban stormwater systems to more frequent and severe storms is projected to exceed $500 million for the Midwest by the end of the century. At-risk communities, including low-income or minority communities, in the Midwest are also becoming more vulnerable to climate change impacts such as flooding, drought and increases in urban heat islands.[37]

6.1.3. Wisconsin

WICCI climate scientists have "down-scaled" global climate models to project how Wisconsin's climate has been changing and how it might change in the years to come.

The decade from 2010-2019 was the wettest in Wisconsin since records began around 1900. Statewide annual average precipitation during this decade rose to 37.0 inches, a 17% increase over the previous long-term average. Winter precipitation has increased by over 20% since 1950. Extreme weather has generally increased in frequency and magnitude (including high heat, extreme amounts of rain or snow, high winds, droughts or extreme cold). Heavy daily precipitation events across Wisconsin show a rising trend in recent decades. Days with 1- to 2-inch rain events have increased the most, but 3-inch rainfalls are also increasing. From 2010 to 2019, Wisconsin experienced at least 21 rainfall events throughout the state that exceeded the 100-year event.[12]

Warming trends in Wisconsin have also continued, with average temperatures in Wisconsin increasing by 3°F since the 1950s. All seasons and regions of Wisconsin are getting warmer and wetter, but winters are warming more rapidly than summers. Cold periods have been getting less common, and this trend is predicted to continue.[12]

Extreme events in nearly every region of Wisconsin are causing disruptions and impacting health, economy and natural resources. The warmer and wetter trends are expected to continue into the future, with wide-ranging consequences throughout Wisconsin's natural and built environments. Examples of climate impacts to natural environment in Wisconsin include flooding and erosion; fewer days of ice cover on the lakes; more ticks in the woods; waterlogged soils that delay planting and harvesting; more harmful algal blooms; and habitat changes. Climate change may also affect public health and safety, forest product industry, agriculture, and tourism and outdoor recreation in the state.[40]

The 2021 WICCI Assessment Report analyzed Wisconsin's projected climate under two different future climate scenarios, based on a mid-range and high-end estimate of future GHG emissions.[41] Both the high-end and mid-range emissions scenarios suggest that average temperatures in Wisconsin will be about 7 to 16°F degrees warmer compared to baseline climate conditions at the end of the 20th century. Further into the future, the emissions scenarios diverge dramatically and show a difference of 6 degrees between each other by the late 21st century (2081-2100), as

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[39] *United States Global Change Research Program (USGCRP). 2017. Climate Science Special Report: Fourth National Climate Assessment, Volume I. https://science2017.globalchange.gov/chapter/6/. Accessed 30 May 2024.*

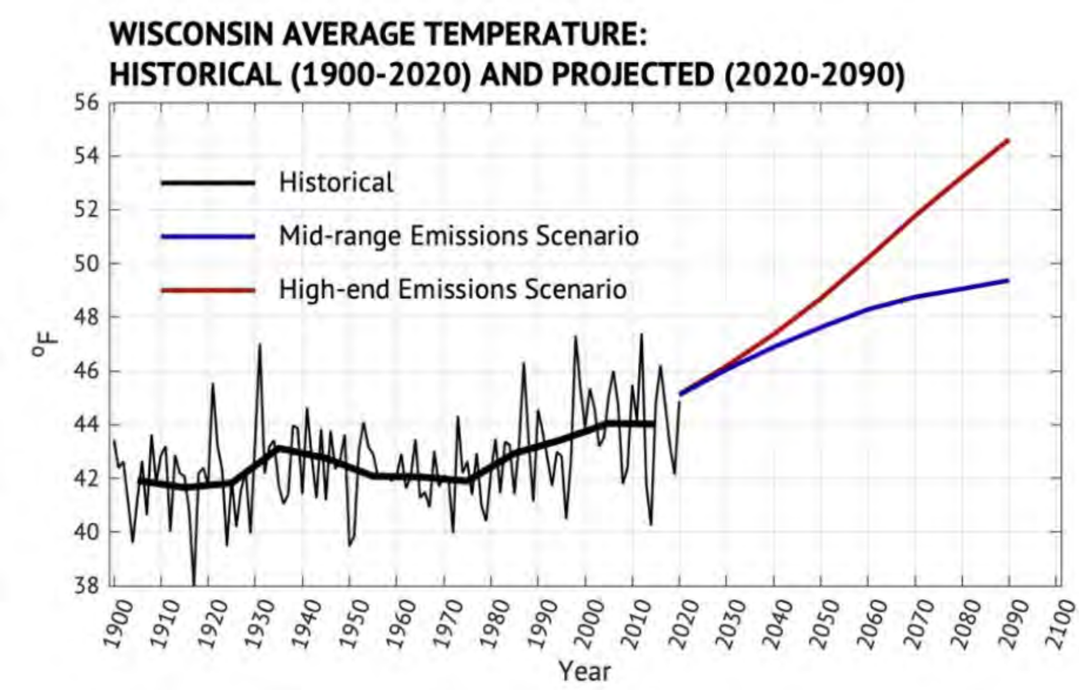
[40] *Wisconsin Department of Natural Resources (WDNR). 2024. Climate Change Impacts in Wisconsin. https://dnr.wisconsin.gov/climatechange/impacts. Accessed 30 May 2024.*

[41] *WICCI (2021), supra note 12 on page 3-2*

shown on Figure 6-1. Wisconsin's historical warming (black line) is expected to continue into the coming century under both a high-end emissions scenario (red curve) and mid-range emissions scenario (blue curve).

Each additional degree of warming will intensify the climate impacts described in this report. These changes in average temperature will increase the frequency and magnitude of many extreme weather events. By 2050, extreme heat days over 90°F in Wisconsin will likely triple.[42] These drastic warming rates for the high-end emissions scenario indicate the importance of mitigation for reducing impacts of climate change.

Figure 6-1: Wisconsin Historical Average Temperatures



Source: Wisconsin Initiative on Climate Change Impacts[43]

Annual mean rainfall in Wisconsin is expected to increase by mid-century, but the change varies among models from a 5% decrease to a 15% increase.[44] Wisconsin is likely to continue to trend toward wetter conditions, especially during winter, spring and fall. Extreme rain events will also increase significantly. Extreme precipitation events are likely to remain most common in the southern and western parts of the state.[12]

6.2. Resilience and Adaptation to Climate Change

Resilience is the ability to anticipate, prepare for and adapt to changing conditions and withstand, respond to and recover rapidly from disruptions.[45] In the study area, warmer temperature and more frequent extreme precipitation events are likely to contribute to potential hazards along the study corridor under the No Build and Build alternatives.

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[42] *Ibid.*

[43] *Wisconsin Initiative on Climate Change Impacts (WICCI). https://wicci.wisc.edu/. Accessed 8 August 2024.*

[44] *Wisconsin Initiative on Climate Change Impacts (WICCI). 2020. Report to the Governor's Task Force on Climate Change: Strategies to Improve Wisconsin's Climate Resilience and Readiness. https://wicci.wisc.edu/wp-content/uploads/wicci-report-to-governors-task-force.pdf. Accessed 30 May 2024.*

[45] *Federal Highway Administration (FHWA). 2014. FHWA Order 5520. Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events. https://www.fhwa.dot.gov/legsregs/directives/orders/5520.cfm. Accessed 30 May 2024.*

6.2.1. Federal Effort Addressing Climate Change Effects

Under NEPA, WisDOT is obligated to comply with all applicable federal laws, regulations, policies and guidance. The Fourth National Climate Assessment, published in 2018, presents the foundational science and the "human welfare, societal, and environmental elements of climate change and variability for 10 regions and 18 national topics, with particular attention paid to observed and projected risks, impacts, consideration of risk reduction, and implications under different mitigation pathways."

The USDOT Policy Statement on Climate Change Adaptation committed USDOT to "integrate consideration of climate change impacts and adaptation into the planning, operations, policies, and programs of DOT in order to ensure that taxpayer resources are invested wisely, and that transportation infrastructure, services and operations remain effective in current and future climate conditions".[46] The U.S. Department of Transportation Climate Adaptation Plan followed up with a statement of policy to "accelerate reductions in greenhouse gas emissions from the transportation sector and make our transportation infrastructure more climate change resilient now and in the future," following this set of guiding principles:[47]

- Use best available science
- Prioritize the most vulnerable
- Preserve ecosystems
- Build community relationships
- Engage globally

USDOT developed its climate action plan pursuant to EO 14008, "Tackling the Climate Crisis at Home and Abroad" (January 27, 2021). EO 14008 recognized the threats of climate change to national security and ordered federal government agencies to prioritize actions on climate adaptation and resilience in their programs and investments.[48]

FHWA Order 5520, Transportation System Preparedness and Resilience to Climate Change and Extreme Weather Events, established FHWA policy to strive to identify the risks of climate change and extreme weather events to current and planned transportation systems.[49] FHWA has developed guidance and tools for transportation planning that foster resilience to climate effects and sustainability at the federal, state and local levels.

6.2.2. State Strategies

The 2021 WICCI Assessment Report[12] identifies specific steps to take to protect the communities, natural resources and the economy from climate change effects. Examples of these steps including helping local communities become more resilient by investing in flood risk reduction practices, pre-disaster mitigation programs and comprehensive planning; and designing and building infrastructure that accounts for future climate conditions.[12]

WICCI has also released the climate science information and potential approaches for addressing the impacts in a Report to the Governor's Task Force on Climate Change: Strategies to Improve Wisconsin's Climate Resilience and Readiness.[44] The strategy and solution for infrastructure in the report include:

- Encourage (and require where appropriate) that all new infrastructure planning and design projects specifically consider vulnerability and risk associated with future climate conditions.

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[46] *United States Department of Transportation (USDOT). 2011. Policy Statement on Climate Change Adaptation. https://www.transportation.gov/sites/dot.gov/files/docs/Policy_on_Aaptation2011.pdf. Accessed 30 May 2024.*

[47] *United States Department of Transportation (USDOT). 2021. U.S. Department of Transportation Climate Adaptation Plan. https://www.transportation.gov/sites/dot.gov/files/docs/DOT%20Adaptation%20Plan.pdf. Accessed 30 May 2024.*

[48] *The White House. 2021. Executive Order on Tackling the Climate Crisis at Home and Abroad. https://www.whitehouse.gov/briefing-room/presidential-actions/2021/01/27/executive-order-on-tackling-the-climate-crisis-at-home-and-abroad/. Accessed 30 May 2024.*

[49] *FHWA (2014), supra note 45 on page 6-5*

- Provide new state funding for infrastructure replacement or repair projects to proactively make infrastructure more resilient to future changes.
- Provide a standardized method to evaluate and report embodied carbon emissions from the most commonly used construction materials in Wisconsin and create Environmental Product Declarations for project development, bid evaluation, etc.
- Long-term goals (4-10 years): Pursue climate bonds to accelerate green actions.

6.2.3. WisDOT Climate Resilience Goals and Objectives

Connect 2050[20] is Wisconsin's statewide, multimodal, long-range plan. To enhance the resiliency and reliability of the transportation system, and in accordance with federal requirements, Wisconsin continues to focus on resiliency with infrastructure assessments, like those in the Facilities Repeatedly Requiring Repair and Reconstruction (F4R) database. The F4R program, required by 23 CFR 667, identifies and conducts evaluations of roadways and bridges that have had catastrophic damage resulting in state emergency declarations on two or more occasions. These efforts identify and consider alternatives that will mitigate, or partially or fully resolve, the root cause of the recurring damage. The US 51 North study area is not considered Wisconsin F4R due to Emergency Events.[50]

In addition to F4R, and as part of the Connect 2050 Goal 7: Maximize Transportation System Resiliency and Reliability and its objectives[20], WisDOT is currently developing a flood risk assessment tool to identify locations on the state highway system with the highest risk of experiencing flooding or being significantly impacted by flooding. This tool will use data and a risk-based scoring system combined with a project prioritization method to identify high-risk flood-prone areas for improvement throughout the state at the 0.25-mile level. Extreme flooding events impact the highway system by damaging infrastructure such as roads or bridges, thus reducing mobility for people and goods. The flood risk assessment tool will enhance WisDOT's ability to implement strategic, cost-effective solutions that will increase the resiliency of the highway system. A strategy WisDOT may consider in response to potential flooding events is raising roadway embankments and bridges above flood levels based on climate projections.

WisDOT planning strategies can also make the study corridor more resilient to the climate change effects. These strategies include:

- Planning transportation infrastructure to avoid climate sensitive locations.
- Incorporating climate impacts on transportation infrastructure into broader land use planning such as developing areas to be more climate resilient.

Moving toward 2050, planning, leveraging technology and implementing cost-effective solutions will play a major role in creating a more resilient and reliable system. To be successful, WisDOT will remain vigilant in its preparation by ensuring robust data-driven consideration in the planning, design and prioritization processes and by ensuring responses to incidents such as crashes, flooding and extreme winter weather are well coordinated and efficiently and effectively implemented.

6.2.4. Study Strategies and Resilience

To withstand the climate change effects, especially the effects due to increased temperature and precipitation, the following strategies may be considered during the Study final design:

- Revising pavement composition and design to withstand higher temperatures. Due to the projected increased temperatures and frequency of extreme temperatures, increasing the critical threshold for selecting asphalt binder would be considered for the Study's Build alternatives.

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[50] *Wisconsin Department of Transportation (WisDOT). 2023. F4R (Facilities Repeatedly Requiring Repair and Reconstruction) Segment Map. https://wisdot.maps.arcgis.com/apps/webappviewer/index.html?id=5827551749d44e7cb59b02f3cb8aecc4. Accessed 30 May 2024.*

- Revising highway drainage design standards for local drainage features to withstand increased precipitation intensity and more frequent extreme precipitation events for the Build alternatives.
- Using remote sensing technologies such as pavement temperature, water elevations and flow rates, and wind speeds during highway closure events.
- Developing pre-identified detour routes and providing real-time information to all users, vehicle navigation systems and other vehicle communication systems.

In addition to the design strategies, planning strategies would also make the study corridor more resilient to the climate change effects. In the event of extreme storms and roadway closures, advance preparation would help WisDOT quickly respond and recover from potential climate change hazards. Advanced preparation and planning strategies can include infrastructure assessments after storm or other climate events and the development of extreme weather risk frameworks. Planning strategies may include:

- Developing asset management and maintenance programs to ensure the study corridor infrastructure elements are monitored and remain in good condition for all alternatives.
- Evaluating the resiliency of the detour routes to minimize distance traveled during road closure events.

7.0 Incomplete or Unavailable Information for Specific Climate Change Impacts

The GHG and climate change effects presented in this memorandum were evaluated based on the best available data; the outcomes are affected by limitations in the data available and uncertainties that limit the accuracy of the tools used.

A level of uncertainty exists in the estimation of a project's impact on GHG emissions. Estimates of future GHG emissions can be developed using travel demand, traffic analysis and emissions estimation tools. These tools extrapolate from observed relationships between demographics, economic activity, vehicle and transit usage, emissions under various travel conditions by different vehicle type and available transportation facilities. All of those relationships will evolve in the future, and analysts must inevitably make reasonable assumptions about future growth, shifts in vehicle technology and future project investments. For that reason, "forecasts" are not "predictions" in that they are always contingent on things continuing as we suppose they will, and there is always the possibility that they will not.

In addition, climate models are complex and incorporate many different assumptions. Climate projections can be affected by the limitations in the data and can limit the accuracy of the projections. Some limitations of the GHG emission scenario models are that the scenarios reflect the societal choices over the next century. Future scenarios could change based on different economic, technologic, demographic and policies in the future.

Although there is uncertainty inherent in the analysis, the analysis was conducted using the best available information and tools and provides reasonable comparisons of the GHG and associated impacts between the alternatives.

US 51 (Stoughton Road) North Study Technical Memorandum

Appendix A: GHG Emissions and Social Cost Calculations and Summaries

October 2024

Appendix A: GHG Emissions and Social Cost Calculations and Summaries

Lifecycle CO2e Greenhouse Gas (GHG) Emissions (Modeled using ICE 2.2.8)[1]

Year	Annualized Emissions (over 21-years of analysis period)		Cumulative Emissions (over 21-years of analysis period) (2030 - 2050)	
Scenario	**No-Build**	**Build**	**No-Build**	**Build**
Units	**MT CO2e**	**MT CO2e**	**MT CO2e**	**MT CO2e**
Roadways (Materials, Transportation, Construction and O&M)	275	654	5,779	13,735
Roadway Reconstruction (Materials, Transportation, Construction)	-	294	-	6,171
Culverts (Materials, Transportation, Construction)	-	48	-	999
Pathways (Materials, Transportation, Construction and O&M)	-	7	-	156
Vehicle Operations - Construction Delay	-	340	-	7,133
Vehicle Operations - VMT Operations	23,470	23,470	492,877	492,877
Total Construction, O&M, and Vehicle Operation	23,746	24,813	498,656	521,071
Difference Build vs No-Build	NA	1,067	NA	22,415
Difference Build vs No-Build %	NA	4.50%	NA	4.50%

Notes:
NA = not applicable

1. GHG emission results were obtained from the ICE Version 2.2.8 Tool.

Daily Vehicle Miles Traveled (VMT) Impacted during Construction (Vehicle Operations - Construction Delay)

	No-Build	**Build**
Impacted Average Daily VMT	-	160,098.24

Lifecycle GHG Emissions Summary - Year by Year GHG Emissions

Annualized CO2e Greenhouse Gas (GHG) Emissions

Year	Operation VMT Emissions (CO2e MT/year)[1]		Construction and O&M Emissions (CO2e MT/year) [2]		Estimated Year by Year GHG Emissions (CO2e MT/year)	
	No-Build	Build	No-Build	Build	No-Build	Build
2030	23,470	23,810	275	1,003	23,746	24,813
2031	23,470	23,810	275	1,003	23,746	24,813
2032	23,470	23,810	275	1,003	23,746	24,813
2033	23,470	23,810	275	1,003	23,746	24,813
2034	23,470	23,810	275	1,003	23,746	24,813
2035	23,470	23,810	275	1,003	23,746	24,813
2036	23,470	23,810	275	1,003	23,746	24,813
2037	23,470	23,810	275	1,003	23,746	24,813
2038	23,470	23,810	275	1,003	23,746	24,813
2039	23,470	23,810	275	1,003	23,746	24,813
2040	23,470	23,810	275	1,003	23,746	24,813
2041	23,470	23,810	275	1,003	23,746	24,813
2042	23,470	23,810	275	1,003	23,746	24,813
2043	23,470	23,810	275	1,003	23,746	24,813
2044	23,470	23,810	275	1,003	23,746	24,813
2045	23,470	23,810	275	1,003	23,746	24,813
2046	23,470	23,810	275	1,003	23,746	24,813
2047	23,470	23,810	275	1,003	23,746	24,813
2048	23,470	23,810	275	1,003	23,746	24,813
2049	23,470	23,810	275	1,003	23,746	24,813
2050	23,470	23,810	275	1,003	23,746	24,813

Notes: NA = not applicable

1. Year by year GHG emissions were estimated based on ICE Version 2.2.8 Tool outputs. The cumulative vehicle operation emissions between 2030 and 2050 were obtained from the ICE tool tab "Vehicle_Ops". Annualized Emission was calculated by dividing this cumulative emission by 21.

2. Construction related emissions for each year were calculated by dividing the total construction and vehicle delay emissions by 21 years.

Social Cost GHG Emissions Summary

Unit Social Cost for GHG (2020 dollars per metric ton of GHG) [1]

Pollutant	Emission Year	Discount Rate		
		2.5%	2.0%	1.5%
CO2	2030	144	230	384
	2031	147	234	389
	2032	150	237	394
	2033	153	241	398
	2034	155	245	403
	2035	158	248	408
	2036	161	252	412
	2037	164	256	417
	2038	167	259	422
	2039	170	263	426
	2040	173	267	431
	2041	176	271	436
	2042	179	275	441
	2043	182	279	446
	2044	186	283	451
	2045	189	287	456
	2046	192	291	462
	2047	195	296	467
	2048	199	300	472
	2049	202	304	477
	2050	205	308	482

Notes:

1. Source: Supplementary Material for the Regulatory Impact Analysis for the Final Rulemaking, "Standards of Performance for New, Reconstructed, and Modified Sources and Emissions Guidelines for Existing Sources: Oil and Natural Gas Sector Climate Review" EPA Report on the Social Cost of Greenhouse Gases: Estimates Incorporating Recent Scientific Advances (EPA 2023).

Total Social Cost for Construction, O&M, and Operation (2020 dollars)

Year	2.5% Discount Rate		2.0% Discount Rate		1.5% Discount Rate	
	No-Build	Build	No-Build	Build	No-Build	Build
2030	$3,419,355	$3,573,058	$5,461,470	$5,706,968	$9,118,281	$9,528,155
2031	$3,490,592	$3,647,497	$5,556,453	$5,806,220	$9,237,009	$9,652,220
2032	$3,561,829	$3,721,936	$5,627,689	$5,880,658	$9,355,736	$9,776,284
2033	$3,633,065	$3,796,374	$5,722,671	$5,979,910	$9,450,718	$9,875,536
2034	$3,680,556	$3,846,000	$5,817,653	$6,079,162	$9,569,446	$9,999,601
2035	$3,751,793	$3,920,439	$5,888,890	$6,153,600	$9,688,174	$10,123,665
2036	$3,823,029	$3,994,878	$5,983,872	$6,252,852	$9,783,156	$10,222,917
2037	$3,894,266	$4,069,316	$6,078,854	$6,352,104	$9,901,883	$10,346,981
2038	$3,965,502	$4,143,755	$6,150,091	$6,426,542	$10,020,611	$10,471,046
2039	$4,036,739	$4,218,194	$6,245,073	$6,525,794	$10,115,593	$10,570,297
2040	$4,107,976	$4,292,633	$6,340,055	$6,625,046	$10,234,321	$10,694,362
2041	$4,179,212	$4,367,071	$6,435,037	$6,724,297	$10,353,048	$10,818,426
2042	$4,250,449	$4,441,510	$6,530,019	$6,823,549	$10,471,776	$10,942,491
2043	$4,321,685	$4,515,949	$6,625,001	$6,922,800	$10,590,504	$11,066,556
2044	$4,416,667	$4,615,200	$6,719,983	$7,022,052	$10,709,231	$11,190,620
2045	$4,487,904	$4,689,639	$6,814,965	$7,121,304	$10,827,959	$11,314,685
2046	$4,559,141	$4,764,078	$6,909,947	$7,220,555	$10,970,432	$11,463,562
2047	$4,630,377	$4,838,516	$7,028,675	$7,344,620	$11,089,160	$11,587,627
2048	$4,725,359	$4,937,768	$7,123,657	$7,443,871	$11,207,887	$11,711,691
2049	$4,796,596	$5,012,207	$7,218,639	$7,543,123	$11,326,615	$11,835,756
2050	$4,867,832	$5,086,645	$7,313,621	$7,642,375	$11,445,342	$11,959,820
Cumulative Total	**$86,599,925**	**$90,492,664**	**$133,592,317**	**$139,597,402**	**$215,466,883**	**$225,152,298**

Social Cost Differences between Build and No-Build -Snapshot for 2030 and 2050 Emissions[1]

	2030				2050			
	No-Build	Build	Change (Build vs No-Build)	%Change (Build vs No-Build)	No-Build	Build	Change (Build vs No-Build)	%Change (Build vs No-Build)
2.5%	$3,419,355	$3,573,058	$153,703	4.50%	$4,867,832	$5,086,645	$218,813	4.50%
2.0%	$5,461,470	$5,706,968	$245,498	4.50%	$7,313,621	$7,642,375	$328,753	4.50%
1.5%	$9,118,281	$9,528,155	$409,874	4.50%	$11,445,342	$11,959,820	$514,478	4.50%

Notes:

1. Snapshot emissions for 2030 and 2050 include the annualized emissions obtained from ICE.

Social Cost Differences between Build and No-Build - Cumulative SC-GHG 2030-2050

	No-Build	Build	Change (Build vs No-Build)	%Change (Build vs No-Build)
2.5%	$86,599,925	$90,492,664	$3,892,738	4.50%
2.0%	$133,592,317	$139,597,402	$6,005,085	4.50%
1.5%	$215,466,883	$225,152,298	$9,685,415	4.50%

Annualized GHG Emissions Equivalency for GHG Emissions Increases from Build (Compared to No-Build)

	No-Build	Build
Annualized GHG Emissions Increase (Build vs No-Build, MT/year)	**23,746**	**24,813**
GHG Equivalency (/year)		
Barrels of crude oil consumed	54,977	57,447
Gasoline powered passenger vehicles driven for one year	5,652	5,906
Tanker truck's worth of gasoline	314	328
Natural Gas Fired Power Plant in One Year	0.063	0.066

Notes:

1. Data source: EPA (https://www.epa.gov/energy/greenhouse-gas-equivalencies-calculator)

    1000 MT CO2e is equivalent to

        2,315 barrels of oil consumed.

        238 gasoline powered passenger vehicles driven for one year.

        13.2 Tanker truck's worth of gasoline.

        0.003 Natural Gas Fired Power Plant in One Year.