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CONNECTICUT DEPARTMENT OF TRANSPORTATION

CARBON REDUCTION STRATEGY

Dewberry

FINAL

TABLE OF CONTENTS

1. PURPOSE 3

2. INTRODUCTION & BACKGROUND 4

2.1 Connecticut Demographics 4
2.2 CTDOT Transportation Assets & Use 4
2.3 CTDOT Mission, Vision, and Values 5
2.4 Regional Planning in Connecticut 6
2.5. Recent State Actions on GHG Emissions and Vehicle Miles Travelled 7
2.6 Transportation Emissions in Connecticut 7
2.7 Carbon Reduction Program and Carbon Reduction Strategy 8

3. CARBON REDUCTION STRATEGY PROCESS AND RESULTS 9

3.1 Greenhouse Gas Emissions Inventory and Construction Emissions Analysis 10
3.2 Identification of Potential and Existing Strategies 16
3.3 Final List of Potential Strategies 29
3.4 Solar Assessment of ROW Properties 30

4. NEXT STEPS / IMPLEMENTATION PLAN 32

4.1 Project Selection 33
4.2 Solar in ROW 33
4.3 Development of a Program Evaluation Approach 34

APPENDIX A 35

APPENDIX B 36

APPENDIX C 38

REFERENCES 40

1. PURPOSE

The intent of this document is to provide a Federal Highway Administration-compliant Carbon Reduction Strategy for the state of Connecticut. This document lays out the Connecticut Department of Transportation's (CTDOT's) process for developing, selecting, and evaluating strategies that meet the Carbon Reduction Program eligibility requirements and decrease greenhouse gas (GHG) emissions in the transportation sector. The document also highlights the CTDOT overall GHG emissions inventory and its analysis of GHG emissions from two segments of a newly constructed, $245 million highway widening project. CTDOT has undertaken this effort with regional coordination through Connecticut's Councils of Governments.

Figure 1.1: The East Haddam Swing Bridge over the Connecticut River.

2. INTRODUCTION & BACKGROUND

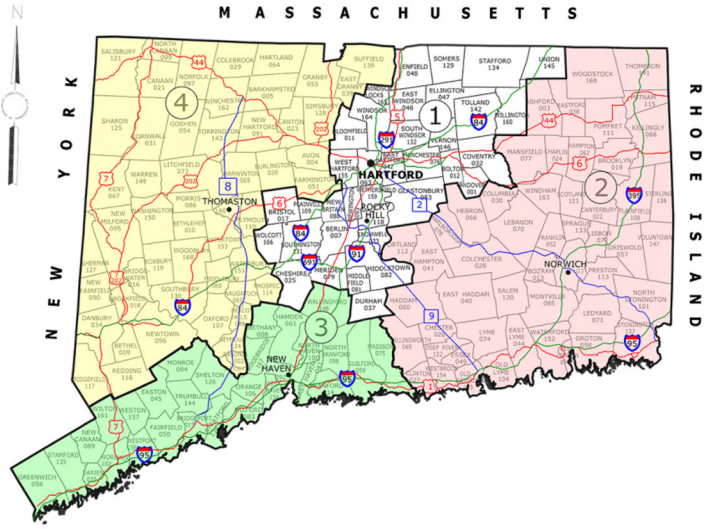
2.1 Connecticut Demographics

The state of Connecticut (population 3.6 million in 2021) has a population density of 744.7 people per square mile and a combination of urban, rural, and suburban communities. The population's age distribution is approximately 20 percent of the state under the age of 18, 20 percent 65 or over, and 60 percent between 19-64. The percentage of the population that is low-income (below 200 percent of the federal poverty level) is 22 percent. Thirty-four percent of the state population identifies as a minority racial or ethnic group. Five percent of households identify as having limited English proficiency.[1] These statistics – and the populations that belie them – are critical to understanding considerations in investment in the state. Following President Biden's Justice40 initiative in January 2021 to direct 40 percent of the benefits stemming from federal investments towards disadvantaged communities, it is important to identify historically and currently underserved communities so that these communities, and the people who live, work, go to school, and visit in them, can benefit from federal and state investments.

2.2 CTDOT Transportation Assets & Use

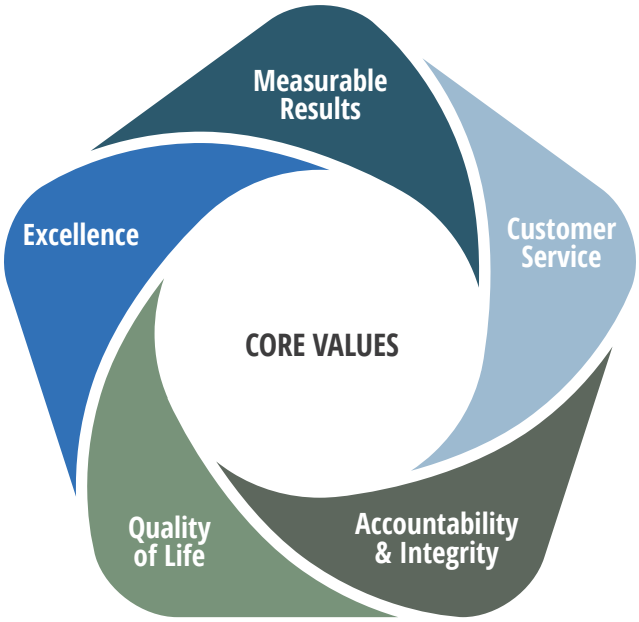
Communities across Connecticut require a mixture of transportation needs, from personal vehicles to mass transit. There are 21,199 miles of public roads in Connecticut.[2] Local roads comprise 65 percent of the state's roads, with collector roads and arterials comprising the next highest categories (both 14 percent). CTDOT maintains 18 percent of the roads, while local municipalities maintain the remaining 82 percent. Connecticut is served by rail (Metro North, CTrail, and Amtrak) as well as bus service. CTDOT operates the majority of the state's bus service through its bus rapid transit (BRT) system, CTfastrak (from New Britain to Hartford), and through CTtransit (serving Hartford, New Haven, Stamford, Waterbury, New Britain, Bristol, Meriden, and Wallingford). CTDOT also supports local bus transit districts. According to the 2020 U.S. Census, Connecticut workers aged 16 and older have an average one-way commute of 26.5 minutes, with an average one-way distance of 15.5 miles. Almost four percent of Connecticut workers use public transit to get to work and 10 percent of workers work from home.[3]

Figure 2.1: Map of Connecticut's highways and CTDOT maintenance and construction districts.



2.3 CTDOT Mission, Vision, and Values

CTDOT's mission is to "provide a safe and efficient intermodal transportation network that improves the quality of life and promotes economic vitality for the State and the region." CTDOT oversees roads and highways, much of Connecticut's public transportation, bicycle and pedestrian projects, and two seasonal ferries across the Connecticut River. CTDOT's vision is to "lead, inspire and motivate a progressive, responsive team, striving to exceed customer expectations."[4] CTDOT emphasizes the following organizational values: measurable results, customer service, quality of life, accountability, integrity, and excellence.



CTDOT is comprised of five bureaus under the office of the CTDOT Commissioner. They include:

- Bureau of Engineering & Construction
- Bureau of Finance & Administration
- Bureau of Highway Operations
- Bureau of Policy & Planning
- Bureau of Public Transportation

Each bureau is comprised of offices responsible for building and maintaining Connecticut's robust transportation system. Individually and collectively, the bureaus can contribute to the reduction of carbon in a variety of ways.

Figure 2.2: CTrail Hartford Line train across the Connecticut River Bridge.

2.4 Regional Planning in Connecticut

Metropolitan Planning Organizations (MPOs) are required by federal statute and have the purpose of carrying out the federal transportation planning process on a regional level. MPOs represent areas with populations over 50,000 people. Connecticut has eight MPOs and Connecticut's nine Councils of Governments (COGs) function as the host agencies for those MPOs. COG staffers perform the transportation planning activities for the MPOs, and the rural planning regions, and coordinate with CTDOT on transportation planning activities. Connecticut's COGs are:

- **Capitol Region COG** (Andover, Avon, Berlin, Bloomfield, Bolton, Canton, Columbia, Coventry, East Granby, East Hartford, East Windsor, Ellington, Enfield, Farmington, Glastonbury, Granby, Hartford, Hebron, Manchester, Mansfield, Marlborough, New Britain, Newington, Plainville, Rocky Hill, Simsbury, Somers, South Windsor, Southington, Stafford, Suffield, Tolland, Vernon, West Hartford, Wethersfield, Willington, Windsor, Windsor Locks)
- **CT Metropolitan COG** (Bridgeport, Easton, Fairfield, Monroe, Stratford, Trumbull)
- **Lower CT River Valley COG** (Chester, Clinton, Cromwell, Deep River, Durham, East Haddam, East Hampton, Essex, Haddam, Killingworth, Lyme, Middlefield, Middletown, Old Lyme, Old Saybrook, Portland, Westbrook)
- **Naugatuck Valley COG** (Ansonia, Beacon Falls, Bethlehem, Bristol, Cheshire, Derby, Middlebury, Naugatuck, Oxford, Plymouth, Prospect, Seymour, Shelton, Southbury, Thomaston, Waterbury, Watertown, Wolcott, Woodbury)
- **Northeastern CT COG** (Ashford, Brooklyn, Canterbury, Chaplin, Eastford, Hampton, Killingly, Plainfield, Pomfret, Putnam, Scotland, Sterling, Thompson, Union, Voluntown, Woodstock)
- **Northwest Hills COG** (Barkhamsted, Burlington, Canaan, Colebrook, Cornwall, Goshen, Hartland, Harwinton, Kent, Litchfield, Morris, New Hartford, Norfolk, North Canaan, Roxbury, Salisbury, Sharon, Torrington, Warren, Washington, Winchester)
- **South Central Region COG** (Bethany, Branford, East Haven, Guilford, Hamden, Madison, Meriden, Milford, New Haven, North Branford, North Haven, Orange, Wallingford, West Haven, and Woodbridge)
- **Southeastern CT COG** (Bozrah, Colchester, East Lyme, Franklin, Griswold, City of Groton, Town of Groton, Borough of Jewett City, Lebanon, Ledyard, Lisbon, Montville, New London, North Stonington, Norwich, Preston, Salem, Sprague, Stonington, Borough of Stonington, Waterford, Windham)
- **Western CT COG** (Bethel, Bridgewater, Brookfield, Danbury, Darien, Greenwich, New Canaan, New Fairfield, New Milford, Newtown, Norwalk, Redding, Ridgefield, Sherman, Stamford, Weston, Westport, Wilton)

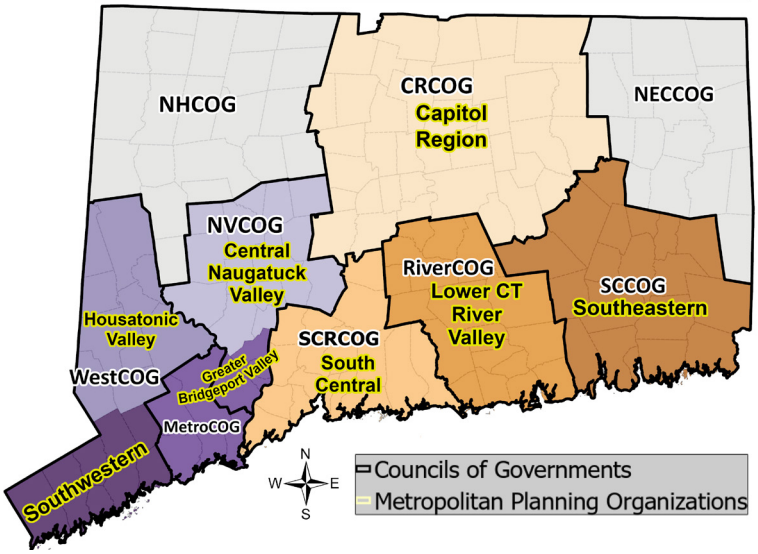


Figure 2.3: Map of Connecticut Council of Governments and Metropolitan Planning Organizations.

2.5. Recent State Actions on GHG Emissions and Vehicle Miles Travelled

Connecticut's leadership on climate change, resilience, and sustainability is evident through its Executive Orders and Public Acts, some of which were enacted as early as 2004. Legislation has been broad reaching in addressing emission reduction strategies and includes measures such as adopting more stringent vehicle emission standards, state fleet electrification (including bus fleets), setting vehicle miles traveled (VMT) reduction targets for agencies, establishing statewide GHG emissions reduction targets, publishing an inventory of GHG emissions, and integrating sea level rise projections into planning documents.

- **Public Act 22-25 (2022)**[5] includes actions to reduce transportation sector GHG emissions, improve air quality, and works to mitigate impacts from climate change.
- **Executive Order 21-3 (2021)**[6] directs CTDOT to move to a Statewide battery electric bus fleet by 2035. The Executive Order (EO) notes that "The DOT shall: cease purchasing or providing state funding to third parties for the purchase of diesel buses by the end of 2023; create an implementation plan which identifies any barriers to full bus fleet electrification; and set a 2030 vehicle miles traveled (VMT) reduction target and develop a plan of investments to contribute to and encourage the achievement of such targeted reductions." In response to this Executive Order, CTDOT has proposed a target VMT reduction of five percent per capita by 2030 (baseline from 2019).
- **Executive Order 1 (2019)**[7] requires state agencies to achieve GHG emission reductions of 45 percent below 2001 levels.

2.6 Transportation Emissions in Connecticut

Connecticut's transportation sector is the largest source of the state's greenhouse gas emissions, at almost 40 percent.[8] As noted in Connecticut Department of Energy & Environmental Protection's (CT DEEP's) 1990-2021 Connecticut Greenhouse Gas Emissions Inventory, with the exception of a dip due to COVID travel reductions, "transportation emissions remain near their 1990 levels, despite significant improvements in automobile fuel economy over the past 3 decades. Improvements in fuel economy have reduced emissions per mile traveled, but those reductions have been offset by an increase in the overall number of miles driven." This report notes "the state will face difficulties meeting" the 2030 goals, which are "a 29 percent reduction of transportation sector emissions from 2014 levels."[9]

Emissions in this sector disproportionately impact the state's low income communities.[10] To address transportation sector emissions, the state has undertaken significant legislation, as noted in Section 2.5. While many of these initiatives come under the purview of CTDOT, it is important to note that meaningful, long term reductions in GHG emissions in this sector are also tied to land use changes, additional State and local agencies, and the decisions of the state's residents.

Access the 2023 CT DEEP emissions inventory

"Connecticut's transportation sector ... accounts for approximately **39 percent** of the state's total emission profile and exceeds the total emissions from the next two highest emitters, combustion in individual residences and consumption of electricity, combined. Gasoline is responsible for **77 percent** of the transportation emissions."

1990-2021 CONNECTICUT GREENHOUSE GAS EMISSIONS INVENTORY

2.7 Carbon Reduction Program and Carbon Reduction Strategy

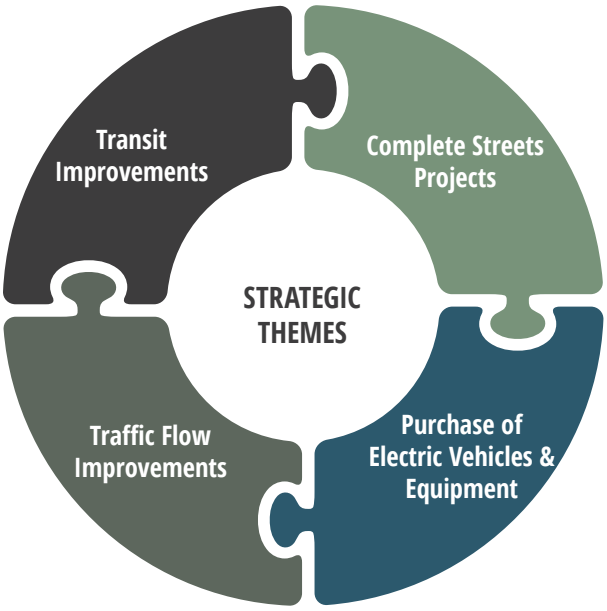
On November 15, 2021, President Biden signed the Infrastructure Investment and Jobs Act (IIJA) (Public Law 117-58, also known as the "Bipartisan Infrastructure Law" [BIL]) into law. The BIL authorized a new Carbon Reduction Program (CRP) to reduce transportation emissions.

The purpose of the CRP is to reduce transportation emissions through the development of State carbon reduction strategies and by funding strategies designed to reduce transportation emissions. Transportation emissions are defined as "carbon dioxide emissions from on-road highway sources" (See 23 U.S. Code § 175 as established by the IIJA/BIL § 11403).

The FHWA issued CRP Implementation Guidance on April 22, 2022. To access CRP funds, states must create and submit to the FHWA a Carbon Reduction Strategy (CRS) by November 15, 2023. This document is required to be updated at least once every four years. Connecticut's estimated five-year total funding to be received under this program is $79 million (65 percent to be obligated based on population; 35 percent to be obligated anywhere in the state).[11]

CTDOT's CRS stems from four places: (1) Connecticut's overarching GHG and VMT reduction goals; (2) a detailed analysis of GHG emissions from Connecticut's transportation sector; (3) project and strategy evaluation; and (4) outreach and feedback from local transportation planning bodies across Connecticut.

Recognizing the emissions from the transportation sector comprise almost 40 percent of the state's GHG emissions, it is important to understand that CTDOT's CRS is a strategy, not a statewide plan, and identified projects and strategies are bound to the requirements of the CRP. Like the state and its communities, strategies addressed in this document are varied – reflecting the many needs across Connecticut as well as the many ways to lower carbon emissions. However, strategies to address GHG emissions tend to fall into a few themes:



These are strategies that fall within the purview of FHWA and CTDOT.

This CRS, laid out in the pages below, is just the beginning. The strategies examined here will need further refinement, analysis, and community feedback. Implementation of these strategies will undergo evaluation so that the anticipated carbon reduction goals can be met.

Connecticut's estimated five-year total funding to be received under the CRP is **$79 million**.

3. CARBON REDUCTION STRATEGY PROCESS AND RESULTS

Connecticut's leadership in climate change, resilience, and sustainability is evident in its legislation and executive orders which dovetail with the goals of the CRP. CTDOT's CRS is informed by its establishment of a GHG inventory and estimated embodied carbon of a construction project as well as its engagement with the state's COGs for their localized knowledge of needed current and potential carbon reduction strategies.

CTDOT identified potential strategies, some of which are currently being undertaken by CTDOT ("existing") and some of which are new ideas ("proposed"), that could be good candidates for this funding source. Working across departments, the agency developed potential prioritization factors to assist in selecting which strategies would get funded.

CTDOT presented the potential strategies and prioritization factors to Connecticut's nine COGs at two meetings in July and August 2023. At the meetings, the COG representatives learned about CTDOT's CRS development process, its status, and had the opportunity to provide feedback. The COGs suggested existing and new strategies, weighed in on the prioritization criteria, and suggested a "fatal flaw" analysis. From this coordination with the COGs, CTDOT revised the list of strategies, refined prioritization factors, and developed a fatal flaw analysis.

As a final step, the strategies and programs that passed the fatal flaw analysis were evaluated using a prioritization factor analysis. This analysis was run to see the strengths and weaknesses of a potential strategy. The results of these analyses, as well as the draft CRS, were presented to the COGs in October for their feedback.

After the CRS submittal to FHWA, CTDOT will select the strategies from this list to further develop and implement. CTDOT will also define a program evaluation framework to evaluate each strategy's success once complete. The evaluation framework will be aligned with the requirements outlined in Executive Order 1 (2019) and Executive Order 21-3 (2021), which state that the carbon reduction strategies pursued by CTDOT must assist the state to make meaningful reductions in its GHG emissions and VMT.

Figure 3.1: Route 67 and Grove Street Construction in New Milford.

3.1 Greenhouse Gas Emissions Inventory and Construction Emissions Analysis

To establish a GHG emission baseline, CTDOT undertook a department-wide inventory which examined the primary sources of CTDOT's emissions. As an approved activity under the CRP, CTDOT also developed a construction emissions analysis for a typical project. These analyses provide a more holistic picture of CTDOT's emissions as well as offer a glimpse of the emissions embedded in CTDOT's construction practices. Equipped with this knowledge, CTDOT can meaningfully understand the potential emissions reductions stemming from the implementation of CRP strategies and target effective programs to progress on reduction goals.

3.1.1 GHG Emissions Inventory

A GHG inventory calculates the emissions produced over a select period of time. This GHG emissions inventory includes CTDOT's calendar year 2021 emissions within its operational control (Scope 1 and 2 emissions) and its value chain emissions (Scope 3), which includes emissions from customer traffic.

Figure 3.2: Scope 1, 2, and 3 Greenhouse Gas Emissions Diagram *(Source: GHG Protocol)*

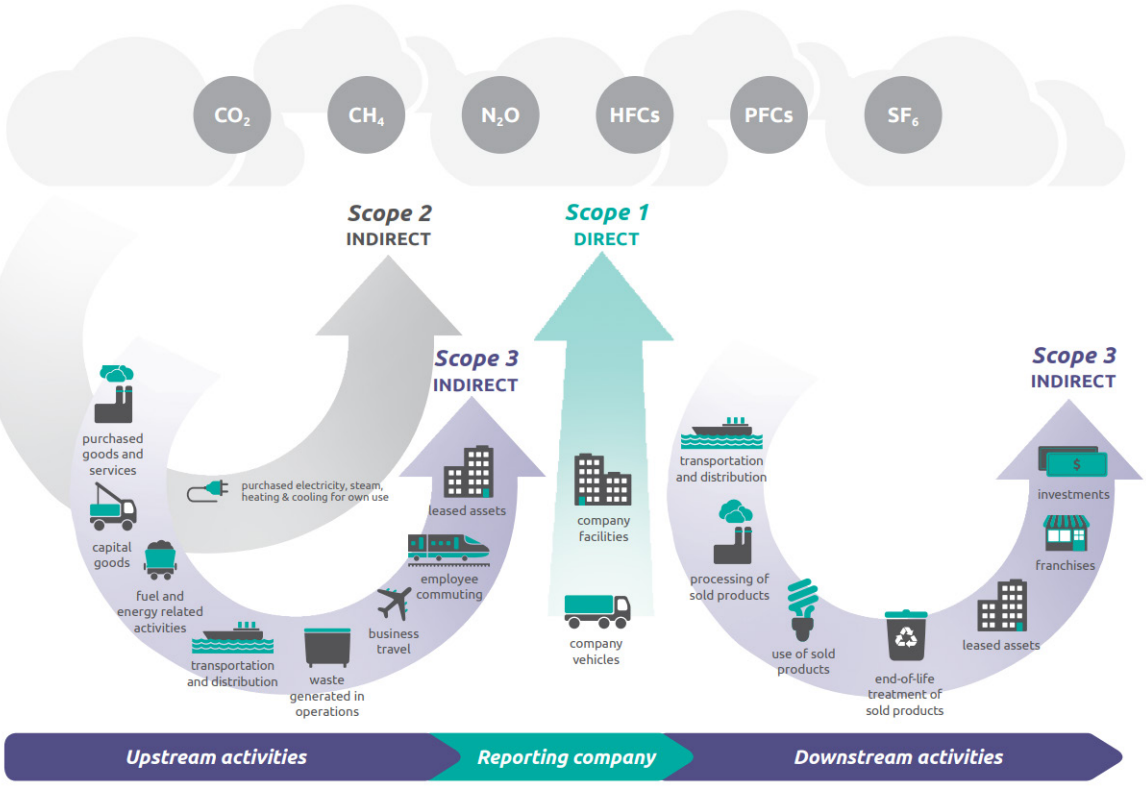


Table 3.1: Emissions and Data Sources

SCOPE	EMISSIONS SOURCE	DATA SOURCE
Scope 1	Generators	CTDOT
	Natural Gas	CT Department of Energy and Environmental Protection - EnergyCAP
	Fleet Vehicle Gas	CTDOT Fuel Control Unit
	Fleet Vehicle Diesel	CTDOT Fuel Control Unit
	Heating Oil (Oil #2)	CT Department of Energy and Environmental Protection - EnergyCAP
	Propane	CT Department of Energy and Environmental Protection - EnergyCAP
	Bus Operations	CTtransit
Scope 2	Electricity	CT Department of Energy and Environmental Protection - EnergyCAP
Scope 3	Customer VMT	CTDOT

CTDOT's Scope 1 emissions, defined as on-site combustion, consist of building fuel consumption and fleet vehicle fuel consumption. Scope 2 emissions, defined as indirect emissions, equate to electricity consumption. Scopes 1 and 2 together are called operational control emissions. This means that CTDOT can directly control and influence the activities associated with emissions. For Scope 3 value-chain emissions, the focus is on the largest emissions source, which is customer VMT. These emissions are not under CTDOT's direct control, but can be influenced by CTDOT.

Most of the emissions factors used in this inventory came from the 2023 U.S. Environmental Protection Agency's (EPA's) Emission Factors Hub. Since 2011, the EPA has been maintaining a database which combines the emissions factors that the EPA has researched or endorsed. Emissions are measured by mass in metric tons (mt). Because there are many different GHGs, all emissions are converted into CO_2 equivalent (CO_2e). Therefore, CTDOT emissions are provided in $mtCO_2e$, or "metric tons of CO_2 equivalent." Most calculations were completed using a spreadsheet provided by the EPA. Other inputs included conversion factors provided by the Climate Register and the EPA MOVES4 modeling tool used to calculate VMT emissions. **Table 3.1** details the different emission sources that have been identified and their source. Data were collected internally from different departments within CTDOT.

Summing the emissions for all scopes, CTDOT generated 13,286,641 $mtCO_2e$ in calendar year 2021. This is equivalent to powering 1,674,563 homes for one year, according to the EPA. The operational control emissions (Scopes 1 and 2 emissions) total to 57,242 $mtCO_2e$, or the equivalent of powering 7,214 homes. See **Table 3.2**.

Table 3.2: Breakdown of Total Emissions

SCOPE	MT CO_2E	EQUIVALENT (HOMES POWERED FOR ONE YEAR)
Scope 1	45,583	5,745 homes
Scope 2	11,659	1,469 homes
Scope 3	13,229,399	1,667,349 homes
Grand Total	**13,286,641**	**1,674,563 homes**

Table 3.3 provides a breakdown of Scope 1 emissions. Natural gas and heating oil (Oil #2) are both used in facility heating and represent the second and fourth highest impact, respectively. Fleet vehicles provide the next highest number of emissions, with CTDOT's fleet using over 260,000 gallons of diesel fuel and gasoline. CTDOT's buses consumed 3.7 million gallons of diesel fuel, which contributed the highest emissions impact of all Scope 1 emissions. Finally, generators provide the least number of emissions, which come from diesel fuel use, including routine maintenance testing.

Scope 2, as presented in **Table 3.4**, is solely emissions associated with electricity consumption from CTDOT facilities. CTDOT consumed over 47,000,000 kilowatt-hours (kWh) in 2021, resulting in 11,659 mt CO_2e. For comparison, the average U.S. home uses approximately 11,000 kWh per year.

Table 3.5 provides a breakdown of Scope 3 emissions from activities outside of operational control.

Customer VMT considers the emissions of all private, commercial, and public vehicles. Emissions were estimated using the EPA's Motor Vehicle Emissions Simulator Version 4.0 (MOVES4), released in August 2023. Relevant datasets, including VMT by vehicle type, weather, vehicle mix information, and other inputs consistent with previous CTDOT MOVES analyses, were used. With Connecticut's dense network of highly traveled roads, VMT emissions totaled nearly 29 billion miles, accounting for 13,229,399 mtCO_2e of emissions. This statewide number is consistent with previous reporting methodologies and publicly reported figures.

Table 3.3: Breakdown of Scope 1 Findings

EMISSIONS SOURCE	MT CO_2E
Generators	100
Natural Gas	4,138
Fleet Vehicle Gas	796
Fleet Vehicle Diesel	1,829
Heating Oil (Oil #2)	1,110
Propane	4
Bus Operations	37,605

Table 3.4: Breakdown of Scope 2 Findings

EMISSIONS SOURCE	MT CO_2E
Electricity	11,659

Table 3.5: Breakdown of Scope 3 Findings

EMISSIONS SOURCE	MT CO_2E
Customer VMT	13,229,399

CTDOT's buses consumed **3.7 million gallons** of diesel fuel, which contributed the highest emissions impact of all Scope 1 emissions.

Figure 3.3: Workers performing resurfacing for bridge safety improvements on Route 2.

Under Executive Order 1 (EO 1), Connecticut agencies must undertake yearly Sustainability Performance Plans (SPPs). These plans depict each agency's progress towards the reduction goals set out by EO 1. CTDOT's FY 2021 SPP, which provides information on CO_2 emissions, has some similarities and some differences with the GHG emission inventory undertaken for the CRS. At the most basic level, the GHG emissions inventory undertaken for the CRS has an additional scope of emissions; this inventory includes Scope 3 emissions while the SPP only includes Scopes 1 and 2. Fuel use is also measured differently in the two documents. The SPP includes all fuel used by CTDOT and other agencies that use CTDOT's fuel and fueling infrastructure, while the CRS GHG emissions inventory strictly focuses on fuel use only from CTDOT vehicles. Finally, there are minor differences in the activity data (e.g., amount of electricity consumed) based on when the data was pulled from CTDOT's EnergyCap system. Despite these differences, natural gas and electricity use for CTDOT are approximately the same and within acceptable margins of error. See **Table 3.6** for the comparison of CO_2 emissions of the SPP and CRS.

Table 3.6: Comparison of CO_2 Emissions of the SPP and CRS Inventories

EMISSIONS SOURCE	MT CO_2E SPP	MT CO_2E CRS
Generators	N/A	100
Natural Gas	3,939	4,138
Fleet Vehicle Gas	6,732	796
Fleet Vehicle Diesel	17,602	1,829
Bus Operations	N/A	37,605
Electricity	12,178	11,659
Heating Oil (Oil #2)	1,269	1,110
Propane, etc.	4	4

Figure 3.4: Aerial view of the I-91 Charter Oak Bridge Project.

3.1.2 Construction Emissions Analysis

An analysis of a CTDOT construction project was completed using the FWHA's Infrastructure Carbon Estimator (ICE), developed by the consulting firm ICF and state departments of transportation in Minnesota (lead), California, Colorado, Iowa, New York, Texas, and Washington State. The project chosen by the CTDOT is two sections of the I-91 Charter Oak Bridge Project, 63-703 and 159-191. The "congestion buster"[12] project – which significantly reduced congestion at the 1-91/I-84 interchange – connects I-91 Northbound with Route 5/15 Northbound in Hartford. The project was completed in November 2022 at a cost of $245 million. The project has won numerous awards, including the American Council of Engineering Companies of Connecticut (ACEC-CT) Engineering Excellence Award in 2023.[13]

The purpose of the construction emissions analysis was to pilot the ICE tool and establish a baseline of the emissions for large-scale projects. ICE was developed as a Microsoft Excel-based modeling tool which calculates the net-embodied carbon of a project from its construction, use, and maintenance to its end of life. Net-embodied carbon refers to the carbon impact of the construction materials, the material transportation, the construction itself, and the operations and management of the project to its end of life. To facilitate this calculation, program inputs were separated based on project components: bridge construction, culverts, lighting, roadways, vehicle operations, and signage. After the project specifications were inputted, results were aggregated based on project components and for the project overall. Results are shown in **Table 3.7**.

Table 3.7: ICE Findings

PROJECT	MT CO_2E
63-703: Relocation of Interstate 91 Northbound Exit 29 and Widening of I-91 Northbound and Routes 5/15 Northbound to I-84 East	59,694
159-191: Resurfacing, Bridge, and Safety Improvements on I-91	199
Grand Total	**59,893**

Figure 3.5 shows the annualized embodied carbon for each segment. Note that VMT impacts for both segments from drivers on I-91 are only included in 63-703 (Exit Relocation and Widening), so emissions from VMT in the use phase is the largest source. Operations and maintenance (O&M) is the largest source of emissions for 159-191 (Bridge Resurfacing and Safety Improvements).

Figure 3.5: Annualized mt CO_2e by Project Aspect for 63-703 (Exit Relocation and Widening) and 159-191 (Bridge Resurfacing and Safety Improvements).

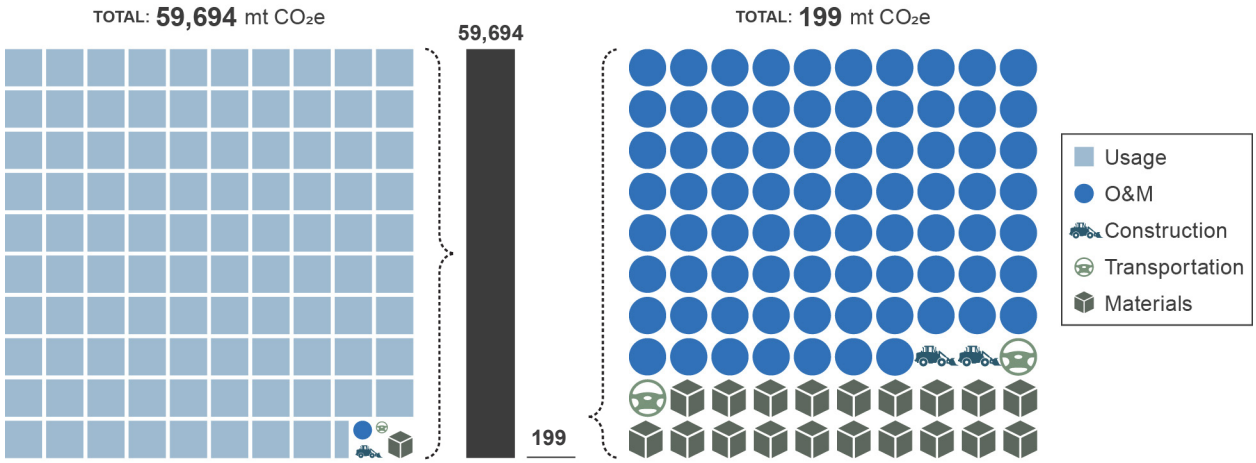
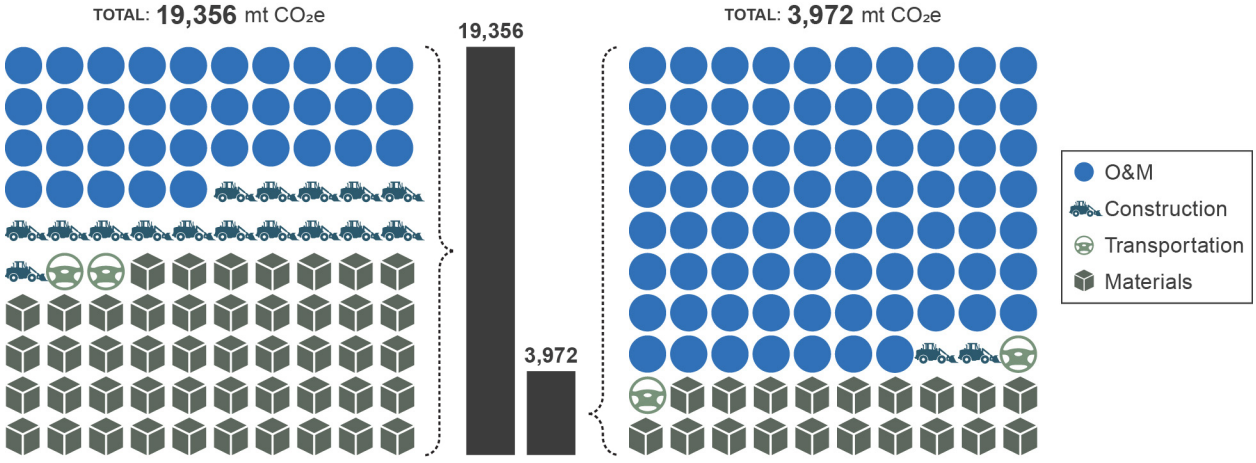


Figure 3.6 shows the lifetime embodied carbon emissions for each segment. Each segment has an estimated lifetime of 20 years. Use phase emissions are not included in the lifetime analysis, since they would significantly over-shadow all other emissions.

For 63-703 (Exit Relocation and Widening), embodied carbon from construction materials and O&M are the most significant sources of emissions. For 159-191 (Bridge Resurfacing and Safety Improvements), O&M is the largest source of emissions.

See **Appendix A** for a more detailed breakdown of embodied carbon emissions.

Figure 3.6: Lifetime mt CO_2e by Project Aspect for 63-703 (Exit Relocation and Widening) and 159-191 (Bridge Resurfacing and Safety Improvements).



3.2 Identification of Potential and Existing Strategies

An initial list of potential and existing carbon reduction strategies (**Table 3.8**) was developed based on CRP eligibility requirements and conversations within CTDOT.

3.2.1 Strategy Prioritization

CTDOT developed an initial list of prioritization factors (**Table 3.9**), developed a definition of the factor, and assigned each factor a weight to show the factor's importance. The prioritization weight was also shared with Connecticut's nine COGs for their feedback.

3.2.2 Coordination with the Council of Governments

Sixty-five percent of the state's CRP funds will be suballocated relative to shares of population in urbanized areas, urban areas, and areas with a population of less than 5,000, enabling the state's COGs and MPOs access to the majority of this funding. The remaining funds may be used anywhere in the state.

The presentation to the COGs included an overview of the CRS, how to develop it, and the content that is required by the FHWA. Strategy eligibility requirements, example strategies, and other potential eligible strategies were reviewed. CTDOT's preliminary CRS approach and key dates, including future COG feedback was discussed. The list of initial strategies that CTDOT identified and potential prioritization weight was shared with the COGs. The COGs were asked for feedback on both the strategies list and prioritization factors. After the virtual meeting, the COGs were asked to share any additional thoughts on the CRS outline, strategies, prioritization factors, and their weights by August 11, 2023.

The COGs provided feedback on additional strategies. There was discussion on the potential prioritization, and agreement from the COGs on the CRS outline and process.

COG representatives suggested potential additional strategies:

- Additional bus rapid transit projects;
- Undertake facility energy efficiency projects;
- Promote transit use with funds for transit access, transit advertising, and user technology improvements;
- Establish an expanded tree planting program;
- Improve bike safety with wider sidewalks;

Table 3.8: Initial List of Potential and Current Carbon Reduction Strategies

EXISTING STRATEGIES	POTENTIAL STRATEGIES
Bus Electrification	E-Bike Chargers in Transit Garages
Bus Rapid Transit (BRT) (CTfastrak)*	Electric Maintenance Equipment (Chainsaws, Leaf Blowers, etc.)
Congestion Mitigation and Air Quality (CMAQ) Program	Pedestrian/Bicycle Facilities
Complete Streets	Safe Routes to School Infrastructure Improvements
Coordinated Traffic System	Solar in ROW
EV Fleet Charging	Sustainability Rating System (e.g. LEED for buildings, Envision for infrastructure) Pilot Project
Highway Lighting to LED	
Pollinator Habitat Restoration	
Roundabout Projects	
Transition Internal Combustion Engine (ICE) Fleet to EV	
Transportation Alternatives	

* Though CTfastrak was completed in 2015, additional upgrades may enhance the service.

- Expand the school bike rack program to private schools and develop bike/ped infrastructure and cultural programming to encourage biking and walking to school;
- Provide greater signal coordination with a GIS layer;
- Develop unused CTDOT real estate for transit-oriented development;
- Examine the carbon impact from building materials;
- Help traffic flow with variable speed limits and coordinated ramp signals;
- Promote teleworking vs. commuting;
- Undertake infrastructure improvements that could support transit ridership; and
- Increase data for improvement of the CTrides program.

The COGs' feedback on current and proposed strategies was incorporated, reviewed, and refined. Two strategies mentioned by the COGs – establish an expanded tree planting program and promote teleworking vs. commuting – were discussed but ultimately not included within the strategy list due to CTDOT's lack of control and authority over the underlying regulations and policies. Another potential strategy – expand employee transit and bike benefits – was discussed but not pursued further for the same reason. However, this does not exclude eligible CRP recipients from implementing these strategies within their regions if they have the proper authority.

The strategies were reviewed against Connecticut's Statewide Long Range Transportation Plan, 2018-2050 to ensure alignment with this document. **Tables 3.10 and 3.11** show how the CRP funding could be used for existing strategies that are underway as well as brand new strategies. The COGs provided feedback on the strategy prioritization factors, noting that some factors could be more clearly defined, and some could be incorporated into other priorities. In addition, the COGs suggested creating a fatal flaw analysis. Based on this feedback, a fatal flaw analysis was developed.

The COGs' feedback also resulted in CTDOT reexamining how certain strategy prioritization factors were valued.

Table 3.9: Initial Prioritization Factors

FACTOR	DEFINITION
Alignment with State Goals	Alignment with Connecticut's GHG reduction or VMT reduction goals.
Community Benefits	A broadly defined view of "benefits," looking at whether a community of people may directly benefit from a project.
Cost Effectiveness	A measure of the anticipated cost and emissions reduction of the strategy.
Existing Community Support	Whether a community may support (or oppose) a potential strategy.
Eligibility	Whether the strategy meets the CRP's eligibility requirements.
Regulatory Conflicts	The likelihood of regulatory issue(s) in implementing a strategy.
Reliability	The ability of the strategy to increase the transportation system reliability by increasing service, adding redundancy, or providing new methods of travel.
Safety	The ability of the strategy to increase safety for all roadway users.
Time to Implement	Defined as short-term, medium-term, and long-term.

Table 3.10: Existing Programs that Could be Carbon Reduction Strategies

#	PROGRAM	DESCRIPTION	ALIGNMENT WITH LRTP[16]
1	Bus Electrification	This project would increase funds for Connecticut's Battery Electric Bus Initiative.	• Environmentally friendly transportation that is affordable • Resilient transportation systems
2	Bus Rapid Transit - CTfastrak	CTfastrak, Connecticut's first bus rapid transit (BRT) system, was completed in 2015. CTfastrak runs from Hartford to New Britain. The majority of the route runs on a dedicated bus-only guiderail. Additional funds could be used to support transit enhancements throughout the route.	• Economic growth with efficient and effective transportation for people and goods. • Connectivity to national and global markets to make Connecticut more competitive. • Mobility and accessibility for all users. • Convenient and reliable travel choices. • Integrated transportation and land use for more travel options to connect people and places. • Environmentally friendly transportation that is affordable.
3	CMAQ Projects	CMAQ funds are being utilized in CTDOT's 2021-2024 Statewide Transportation Improvement Program (STIP) for projects including traffic signals, EV chargers at state agencies and town facilities, statewide transportation demand management (TDM), CCTV installation, bus service expansion, pedestrian improvements, and to provide funds to Metro North for the Waterbury Branch service expansion. Projects similar to these and other CMAQ projects could be funded.	• Economic growth with efficient and effective transportation for people and goods. • Connectivity to national and global markets to make Connecticut more competitive. • Mobility and accessibility for all users. • Environmentally friendly transportation that is affordable.
4	Complete Streets	Roadway improvements that make the road safer for all users, from drivers to those on foot to bicyclists. For the CRP, a focus could be on areas with high volumes of commuting traffic including schools, workplaces, shopping centers, community centers, etc.	• Connectivity to national and global markets to make Connecticut more competitive. • Safe and secure travel for people and goods for all modes. • Mobility and accessibility for all users. • Livable, healthy, and environmentally sustainable communities. • Enhanced bicycling and walking accommodations and opportunities.

#	PROGRAM	DESCRIPTION	ALIGNMENT WITH LRTP[16]
5	Coordinated Traffic System	Continue projects statewide that coordinate traffic systems in order to reduce GHG emissions. Projects would include freeway flow control, variable speed limits, coordinated ramp signals and coordinated traffic signals. A potential project could be the expansion of signal service or technology currently being piloted on the Berlin Turnpike, a project recommended in the July 2023 COG meeting.	• Economic growth with efficient and effective transportation for people and goods. • Safe and secure travel for people and goods for all modes.
6	EV Fleet charging	This program would provide funds for EV chargers for CTDOT's fleet.	• Environmentally friendly transportation that is affordable. • Resilient transportation systems.
7	Highway Lighting to LED	This program would continue CTDOT's program to replace high pressure sodium (HPS) roadway lighting with new light emitting diode (LED) fixtures.	• Safe and secure travel for people and goods for all modes. • Resilient transportation systems.
8	Pollinator Habitat Restoration	This program would expand CTDOT's pollinator corridors. These corridors are essential for functioning ecosystems.	• Resilient transportation systems.
9	Roundabout Projects	This program would provide funding to roundabout projects across Connecticut. These projects are effective traffic calming and traffic flow measures.	• Economic growth with efficient and effective transportation for people and goods. • Safe and secure travel for people and goods for all modes.
10	Transition ICE Fleet to EV	Purchase of EV vehicles for CTDOT's fleet.	• Environmentally friendly transportation that is affordable.
11	Transportation Alternatives	The Transportation Alternatives Program (TAP) provides funding for projects and programs that improve biking and walking infrastructure, among other types of projects. CRP funding would fill in the gaps for the existing TAP.	• Mobility and accessibility for all users. • Livable, healthy, and environmentally sustainable communities. • Enhanced bicycling and walking accommodations and opportunities.

Table 3.11: Potential Programs that Could be Carbon Reduction Strategies

#	PROGRAM	DESCRIPTION	ALIGNMENT WITH LRTP[16]
1	Building Energy Efficiency Improvements	Funding would be provided to undertake capital projects at CTDOT buildings to increase their energy efficiency.	• Economic growth with efficient and effective transportation for people and goods.
2	Bus Rapid Transit (BRT) Projects / BRT "light"	Building off the success of CTfastrak, provide funding for BRT projects across Connecticut.	• Economic growth with efficient and effective transportation for people and goods. • Connectivity to national and global markets to make Connecticut more competitive. • Revitalized urban centers with enhanced transportation options. • Mobility and accessibility for all users. • Convenient and reliable travel choices. • Environmentally friendly transportation that is affordable.
3	Consolidation of CTDOT facilities	This potential project would consolidate disparate CTDOT facilities, bringing departments located in different facilities together in one facility. This work is similar to what was does with District 1 Headquarters. Consolidating facilities could lower employee VMT (travel between facilities) and promote ride sharing.	• Integrated transportation and land use for more travel options to connect people and places.
4	Data for CTrides to grow program	CTrides, a program of CTDOT, aims to lower emissions from single occupancy vehicles by working with employers and employees across Connecticut to examine their commuting and teleworking options. CTrides encourages commuting to work with transit, vanpooling, carpooling, biking, or walking. Providing accurate and updated commuter data could help make more informed decisions on where CTrides can focus efforts and expand the program.	• Economic growth with efficient and effective transportation for people and goods. • Convenient and reliable travel choices. • Environmentally friendly transportation that is affordable.

#	PROGRAM	DESCRIPTION	ALIGNMENT WITH LRTP[16]
5	E-bike chargers in Transit garages and enhanced security lockers at transit stations	In order to encourage the use of e-bikes and to help safely charge and store them, the program would install e-bike chargers at Transit garages and enhanced security lockers at stations. This program would be geared towards Transit employees and Transit riders.	• Economic growth with efficient and effective transportation for people and goods. • Livable, healthy, and environmentally sustainable communities. • Enhanced bicycling and walking accommodations and opportunities. • Environmentally friendly transportation that is affordable. • Resilient transportation systems.
6	Electric maintenance equipment (chainsaws, leaf blowers, etc.)	This project would be following in the footsteps of cities like Seattle, which are transitioning to all electric leaf blowers.[17]	• Economic growth with efficient and effective transportation for people and goods. • Resilient transportation systems.
7	Enhancements to promote transit use: Transit access improvements	Projects that improve access to transit (e.g. sidewalk connectivity to promote safely walking to/from transit) would be funded.	• Economic growth with efficient and effective transportation for people and goods. • Connectivity to national and global markets to make Connecticut more competitive. • Revitalized urban centers with enhanced transportation options. • Convenient and reliable travel choices. • Environmentally friendly transportation that is affordable.
8	Enhancements to promote transit use: Transit advertising	Funding for software/technology improvements that would make transit schedules, connections, elevator repair work, and other transit components more accessible to users and draw new riders.	• Economic growth with efficient and effective transportation for people and goods. • Connectivity to national and global markets to make Connecticut more competitive. • Revitalized urban centers with enhanced transportation options. • Improved communications and responsiveness with system users, residents, and businesses. • Convenient and reliable travel choices.

#	PROGRAM	DESCRIPTION	ALIGNMENT WITH LRTP[16]
9	Enhancements to promote transit use: Rail transit improvements	Funding would be provided for rail station improvements and train car upgrades.	• Economic growth with efficient and effective transportation for people and goods. • Connectivity to national and global markets to make Connecticut more competitive. • Revitalized urban centers with enhanced transportation options. • Convenient and reliable travel choices. • Environmentally friendly transportation that is affordable.
10	GIS layer for traffic signal coordination	Having this data would allow COG planners, local governments, and the public to understand the relationship between traffic signals and develop traffic flow projects that would decrease vehicles sitting in traffic and reduce carbon emissions.	• Economic growth with efficient and effective transportation for people and goods. • Safe and secure travel for people and goods for all modes.
11	Pedestrian/bicycle facilities – may include expansion of sidewalk widths on targeted roadways to provide “bike lanes”	A two-part program in which (1) roadways with speeds of over 40 mph would be examined to see if they had sufficient bike lane accommodations; and (2) if they did not, sidewalks on these roadways would be expanded to accommodate bicycles. In line with CTDOT's EO 44 Complete Streets Controlling Design Criteria, sidewalks and bike lanes will be required excluding any exemptions.	• Livable, healthy, and environmentally sustainable communities. • Enhanced bicycling and walking accommodations and opportunities. • Environmentally friendly transportation that is affordable.
12	Safe Routes to School Infrastructure Improvements • Expansion to private and charter schools • Inclusion of a cultural programming aspect • Provision of physical improvements	This potential strategy would provide public and non-public schools (private, parochial, and charter) with bike rack installation to facilitate students’, faculty’s, and staff’s biking to school. The program would also include a bike safety education component to help assist with students’ and their families’ comfortability with biking. The potential program also includes Rectangular Rapid Flashing Beacons (RRFB) and Raised Crosswalks within a ½ mile vicinity of schools in order to promote conditions for active modes of transportation.	• Livable, healthy, and environmentally sustainable communities. • Enhanced bicycling and walking accommodations and opportunities. • Environmentally friendly transportation that is affordable.

#	PROGRAM	DESCRIPTION	ALIGNMENT WITH LRTP[16]
13	Solar installations in ROW	This program would fund a roll out of solar installations in CTDOT's ROW. This project would build upon the examination of potential locations.	• Economic growth with efficient and effective transportation for people and goods.
14	Sustainability rating system pilot project	Funding for CTDOT to undertake a pilot project that will provide a holistic evaluation of a project's sustainability.	• Economic growth with efficient and effective transportation for people and goods.
15	Sustainable construction – use of less carbon intensive construction materials	CTDOT to undertake pilot projects with the Connecticut Advanced Pavement Laboratory to utilize less carbon intensive construction materials. These projects would be monitored and assessed.	• Economic growth with efficient and effective transportation for people and goods.
16	Transit oriented development (TOD) at CTDOT properties	Work has been done to identify TOD opportunities around CTDOT-owned train stations.[18] Expanding on this program would involve CTDOT review of properties to see if any are vacant and may be good candidates for TOD. After candidate sites are found, CTDOT would issue RFPs for housing and mixed use development.	• Revitalized urban centers with enhanced transportation options. • Convenient and reliable travel choices. • Integrated transportation and land use for more travel options to connect people and places. • Livable, healthy, and environmentally sustainable communities.

3.2.3 Analysis and Weighting of Potential Strategies

After the review and refinement from the meetings with the COGs, potential strategies were evaluated in a two-step process. First, a fatal flaw analysis was conducted. Second, each strategy that passed the fatal flaw analysis was run through the prioritization analysis. This section discusses both analyses.

FATAL FLAW ANALYSIS

To determine strategies for inclusion in the CRS, CTDOT, based on feedback from the COGs, developed a fatal flaw analysis. This analysis assessed each strategy against four questions (shown at right).

Table 3.12 shows the fatal flaw analysis results for each strategy. Two strategies that did not pass the fatal flaw analysis are highlighted in yellow. The strategies are building energy efficiency improvements and GIS layer for traffic signal coordination.

Assessment Questions

1. Are there any regulatory conflicts?
2. Is the strategy type fundable under CRP?
3. Can the project be completed within the CRP timeframe?
4. Is the strategy in alignment with the State's GHG emission goals?

Figure 3.7: Bicyclists crossing Merriebrook Lane Bridge over the Mianus River in Stamford.

Table 3.12: Fatal Flaw Analysis

#	PROGRAM	EXISTING (E) OR NEW PROPOSED (P) PROGRAM	LACK OF REGULATORY OR POLICY CONFLICTS	FUNDABLE UNDER CRP	ABILITY TO COMPLETE WITHIN CRP TIMEFRAME	ALIGNMENT WITH STATE'S GHG EMISSION GOALS
1	Bus electrification	E	✓	✓	✓	✓
2	Bus rapid transit (CTfastrak)	E	✓	✓	✓	✓
3	CMAQ projects	E	✓	✓	✓	✓
4	Complete Streets	E	✓	✓	✓	✓
5	Coordinated traffic system	E	✓	✓	✓	✓
6	EV fleet charging	E	✓	✓	✓	✓
7	Highway lighting to LED	E	✓	✓	✓	✓
8	Pollinator habitat restoration	E	✓	✓	✓	✓
9	Roundabout projects	E	✓	✓	✓	✓
10	Transition ICE to EV	E	✓	✓	✓	✓
11	Transportation alternatives	E	✓	✓	✓	✓
12	Bicycle rack installation at schools	P	✓	✓	✓	✓
13	BRT light	P	✓	✓	✓	✓
14	Building energy efficiency improvements	P	✓	Not eligible for CRP funding	✓	✓
15	Consolidation of DOT facilities	P	✓	Potentially fundable	✓	✓

#	PROGRAM	EXISTING (E) OR NEW PROPOSED (P) PROGRAM	LACK OF REGULATORY OR POLICY CONFLICTS	FUNDABLE UNDER CRP	ABILITY TO COMPLETE WITHIN CRP TIMEFRAME	ALIGNMENT WITH STATE'S GHG EMISSION GOALS
16	Data for Ctrides program	P	✓	✓	✓	✓
17	E-bike chargers and lockers	P	✓	✓	✓	✓
18	Electric maintenance equipment	P	✓	✓	✓	✓
19	GIS layer for traffic signal coordination	P	✓	Not eligible for CRP funding	✓	Not aligned
20	Ped/bike enhancements	P	✓	✓	✓	✓
21	Rail transit improvements	P	✓	✓	✓	✓
22	Solar in ROW	P	✓	✓	✓	✓
23	Sustainability rating system pilot project	P	✓	✓	✓	✓
24	Sustainable construction	P	✓	✓	✓	✓
25	TOD at CTDOT properties	P	✓	✓	✓	✓
26	Transit access improvements (e.g. sidewalks)	P	✓	✓	✓	✓
27	Transit software improvements	P	✓	✓	✓	✓

PRIORITIZATION FACTOR ANALYSIS

After the fatal flaw analysis, strategies were assessed using weighted Strategy Prioritization Factors. Based on feedback from the COGs, CTDOT refined some factors' weights. Because many strategies are broadly defined, each strategy was assessed at a high level, qualitatively. This first, high level review allows CTDOT to see each strategy's strengths relative to the prioritization factors. However, because each strategy is broadly defined at this point, strategies are not weighted against each other.

Projects that could increase equity (for example, a transit improvement project or a Complete Streets project that could be located in a low income community) were given an extra point in the Community Benefits factor.

Table 3.13 shows each factor and its prioritization weight.

Table 3.14 provides the definitions of each factor and the evaluation system.

It was determined that the time to implement a project would not be considered in the project's evaluation. While this factor was not weighted to the project's score, it was however noted. Projects were classified as short-term (purchase of equipment/data), medium-term (existing program or expansion of existing project, smaller scale capital program), and long-term (a new program or complex capital project).

Table 3.13: Strategy Prioritization Factors (5 = Most Important)

FACTOR	PRIORITY
Community Benefits	5
Existing Community Support	4
Cost Effectiveness	3
Increases Safety	3
Increases Transportation System Reliability	2.5

Figure 3.8: I-91 Bridge over Ferry Street in New Haven.

Table 3.14: Factor Definition and Evaluation

FACTOR	DEFINITION OF FACTOR	EVALUATION SYSTEM
Community Benefits	A broadly defined view of "benefits," looking at whether a community may directly benefit from a project.	0 = no community benefits 1 = low community benefits (policies internal to DOT or programs only focusing on DOT) 2 = high community benefits +1 point if project could increase equity (e.g. a project scoring "1" would bump up to "2" if equity could be included)
Existing Community Support	Whether a community supports (or opposes) a potential strategy. Many strategies were broad, so potential community support and lack of support was approximated based on strategy type.	0 = No community support or opposition: projects that public isn't well versed in/may not be obvious to the public or may not be supported by the public 1 = Some community support: traffic signal/flow improvements, potentially controversial larger projects (TOD) 2 = A lot of community support: bike/ped projects, transit improvements, projects the public can see (such as solar), projects that have strong supporters (such as the ability to work from home)
Increases Safety	The ability of the strategy to increase safety for all road-way users.	0 = Does not increase safety 1 = Small safety increase 2 = One of project's goals is to increase safety
Increases Transportation System Reliability	The ability of the strategy to increase the transportation system reliability by increasing service, adding redundancy or providing new methods of travel.	0 = Does not increase system reliability 1 = Small reliability increase 2 = One of project's goals is to increase reliability
Cost Effectiveness	Cost per emissions reduction potential.	Potential cost was assessed by: 1 = high cost (large capital project) 2 = medium cost (medium-sized capital project) 3 = low (small capital project, purchase of equip-ment)
		1 = high (projects dedicated to improving air quality, mass transit projects) 2 = low (personal mode shift projects such as bike/ped), department-scale projects

3.3 Final List of Potential Strategies

Carbon reduction strategies were determined by the CTDOT and COG partners. Strategies were analyzed against a fatal flaw analysis consisting of four questions to determine their programmatic eligibility. Strategies that passed this analysis were then analyzed against weighted strategy prioritization factors.

How strategies scored relative to other strategies is shown in **Table 3.15** (strategies currently underway by CTDOT) and **Table 3.16** (new strategies). This first analysis provides CTDOT a sense of each strategies' relative strength and potential weakness in relation to CTDOT's identified CRS priorities. Since strategies are high level, the project development process may yield strengths that are not initially apparent, and thus this initial scoring will be refined. Once projects are identified, a public involvement process could produce project champions, enhancing the level of community support as the project progresses from initial concept into development. To see the complete analysis, refer to **Appendix B**.

Table 3.15: Existing Strategies Scored from Highest to Lowest

EXISTING STRATEGY	SCORING
Complete Streets	37 points
Transportation alternatives	37 points
Bus rapid transit (CTfastrak)	34 points
Coordinated traffic system	31 points
Bus electrification	29 points
Roundabout projects	28 points
CMAQ projects	25 points
EV fleet charging	13.5 points
Pollinator habitat restoration	9.5 points
Transition ICE to EV	9.5 points
Highway lighting to LED	6 points

The draft CRS with preliminary results of the strategies' scoring were presented to the COGs in October for their feedback. CTDOT incorporated feedback provided into this document.

Because all strategies will need to be incorporated into a statewide transportation improvement program (STIP) prior to being funded, strategies were grouped by "existing strategies" and "proposed strategies."

Table 3.16: Proposed Strategies Scored from Highest to Lowest

PROPOSED STRATEGY	SCORING
Safe Routes to School infrastructure improvements	38.5 points
Ped/bike enhancements	37 points
Transit access improvements (e.g. sidewalks)	37 points
Transit software improvements	37 points
E-bike chargers and lockers	32.5 points
BRT light	31 points
Rail transit improvements	31 points
TOD at CTDOT properties	27.5 points
Data for CTrides program	22 points
Solar in ROW	21 points
Sustainability rating system pilot project	16 points
Sustainable construction	16 points
Electric maintenance equipment	9.5 points
Consolidation of CTDOT facilities	8 points

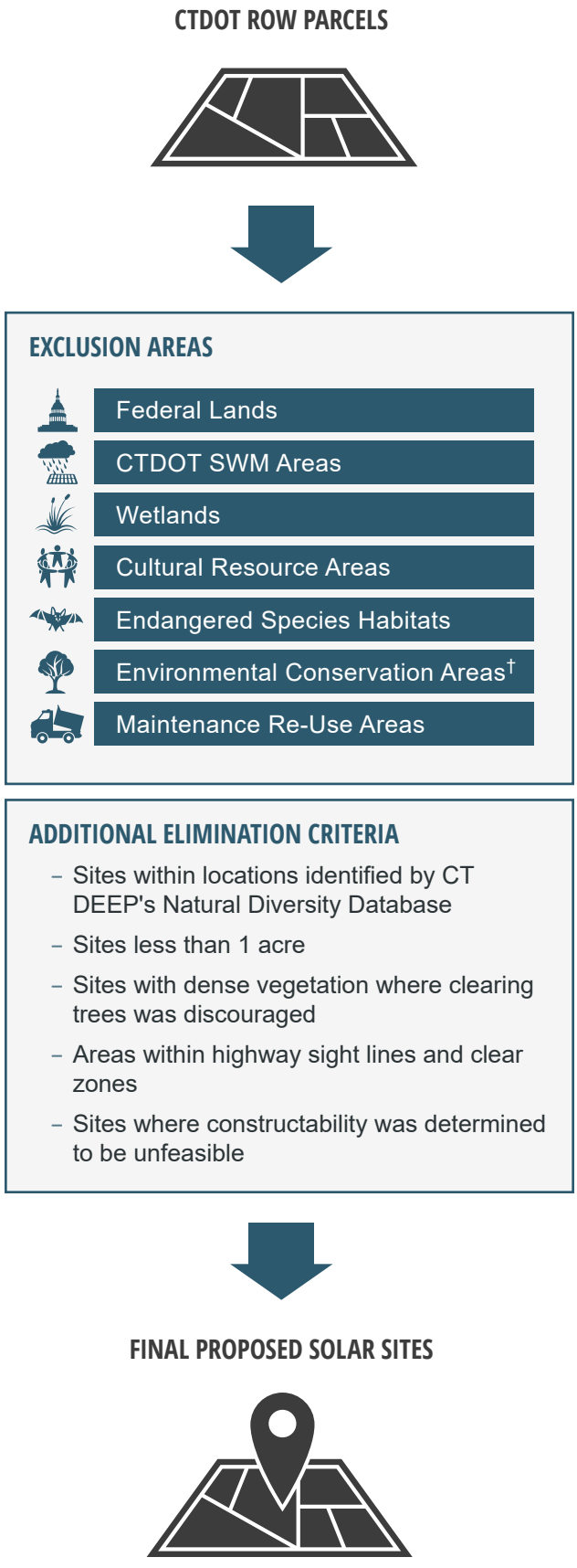
3.4 Solar Assessment of ROW Properties

CTDOT has been pursuing solar energy development at its facilities. As noted in the Annual Capital Plan Report, solar energy development at CTDOT's facilities will "provide clean electric power and lower utility bills."[14] CTDOT has signed solar power purchase agreements for two locations. Building on this work, CTDOT examined the potential to implement solar by assessing the feasibility of its ROW properties to include solar photovoltaic (PV) installations. These installations will take advantage of potentially underutilized space for the production of emissions-free solar energy.

3.4.1 Methodology

CTDOT developed a list of criteria in order to establish a list of suitable PV sites within its ROW. Using ArcGIS, a tool was created that depicted areas within the limits of CTDOT ROW, but outside of the agreed upon exclusions. The exclusion areas datasets were obtained from the National Park Service, U.S. Fish & Wildlife Service National Wetlands Inventory, CT DEEP's Natural Diversity Database, and CTDOT.

The datasets were merged to create a single exclusion area layer. This exclusion area layer was then compared to the CTDOT ROW limits to create a layer, populated with polygons, of available area. Of the polygons that were left from the analysis, many could be removed from consideration due to size or orientation. For example, thin slivers of available area were not considered because of infeasibility of construction along active highways. Similarly, the most densely forested areas were removed from consideration, limiting the amount of tree removal. Connecticut's Natural Diversity Database of threatened and endangered species was compared to the remaining potential sites to understand possible impact to future solar development.



* Environmental conservation areas include pollinator habitats and habitat restoration areas for endangered species.

3.4.2 Potential PV Sites

Using the methodology, a total of 35 potential sites were identified as potentially suitable areas for the construction of PV generation systems, totaling 28.7 MW of estimated output across 139.8 acres (**Figure 3.9**). These sites included rest areas, park and ride parking lots, and open space adjacent to highways.

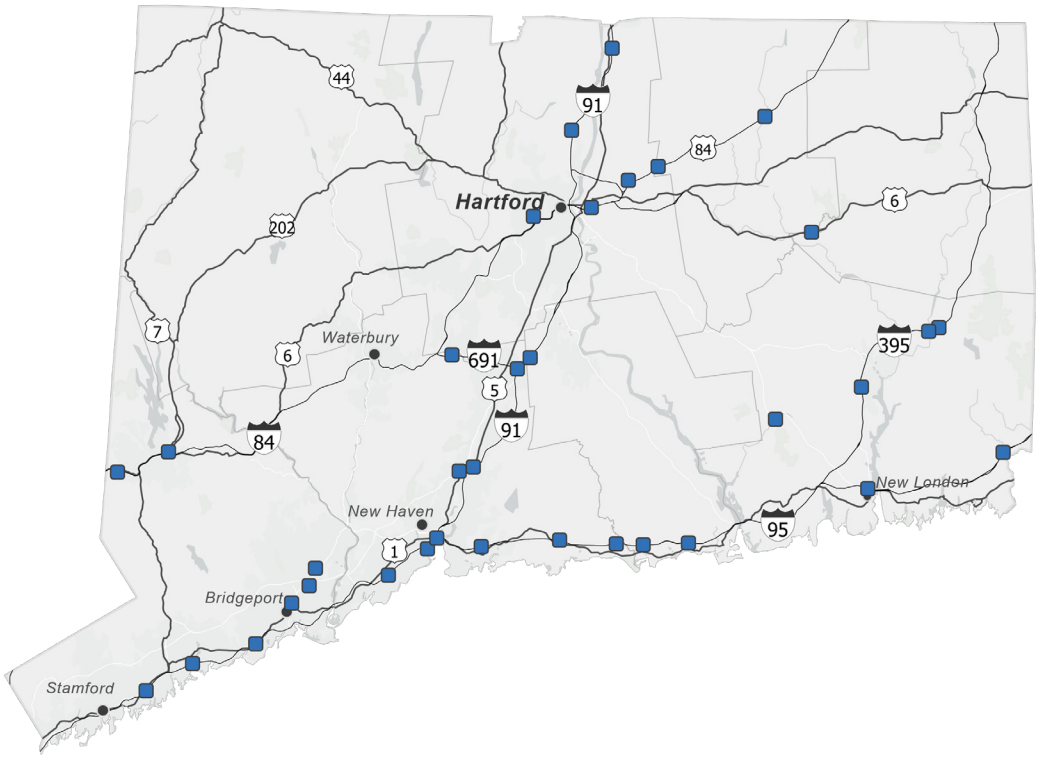
A full list of the potential solar sites is included in **Appendix C**, including the highway and milepost location, total area (in acres), the estimated output (in megawatts), and whether the solar installation would be ground-mounted, on a canopy, or mixed.

ASSUMPTIONS

Three types of solar installations were considered when evaluating the areas that were found to be potential sites; rooftop, carports/canopy, and ground-mount. Rooftops on existing service plaza buildings, welcome centers, or rest areas within CTDOT ROW could be retrofitted with solar panels. Solar canopies could be installed over the top of existing parking lots at these same sites or commuter parking lots within CTDOT ROW. Open space areas along highways and highway interchanges were found to be good candidates for ground-mount solar systems.

Estimating energy output depends on many factors, including (but not limited to) latitude of the site, efficiency of the solar panels, and spacing and orientation of the solar panels to the sun. Rooftop, carport, and ground-mount systems have been shown to generate different amounts of energy per area, so assumptions were made to estimate the output of each of these types of solar installations. It was assumed that 50% of the area of rooftops would be unusable due to existing mechanical equipment and areas required to service the panels. Rooftops would also need to be evaluated structurally for their capacity to hold the solar panels in future analyses. Similarly, rows of ground mount systems must be spaced apart to reduce shading. It was assumed that 20% of the buildable area was left for spacing between rows of solar panels and other electrical equipment. Finally, solar canopies over carports are aligned over existing rows of parking to not interfere with drive aisles, fire access routes, and transit bus movements, so only area of the parking spaces was used to determine canopy area and therefore solar energy output.

Figure 3.9: Map of potential solar sites identified in the ROW assessment.



4. NEXT STEPS / IMPLEMENTATION PLAN

After submission of the CRS to FHWA, strategies listed in this document will need to be further developed as CTDOT decides which strategies to implement. CTDOT and the respective COGs will undertake these efforts, which will follow CTDOT's Public Involvement Process (PIP). As strategies are refined into projects, they will undergo additional analysis to evaluate the extent that each of the projects meet CTDOT's Strategy Prioritization Factors. Projects that are selected to move forward will be incorporated into the COG's Transportation Improvement Program (TIP) and Statewide Transportation Program (STIP), as required by the CRP. After project completion, projects will be evaluated to assess the extent of the project's success in lowering VMT and GHG emissions.

Although a fatal flaw analysis and scoring of potential strategies were completed as part of this report, this will be an iterative process; as this CRS is updated, the analysis can be updated and revised as needed when new information becomes available.

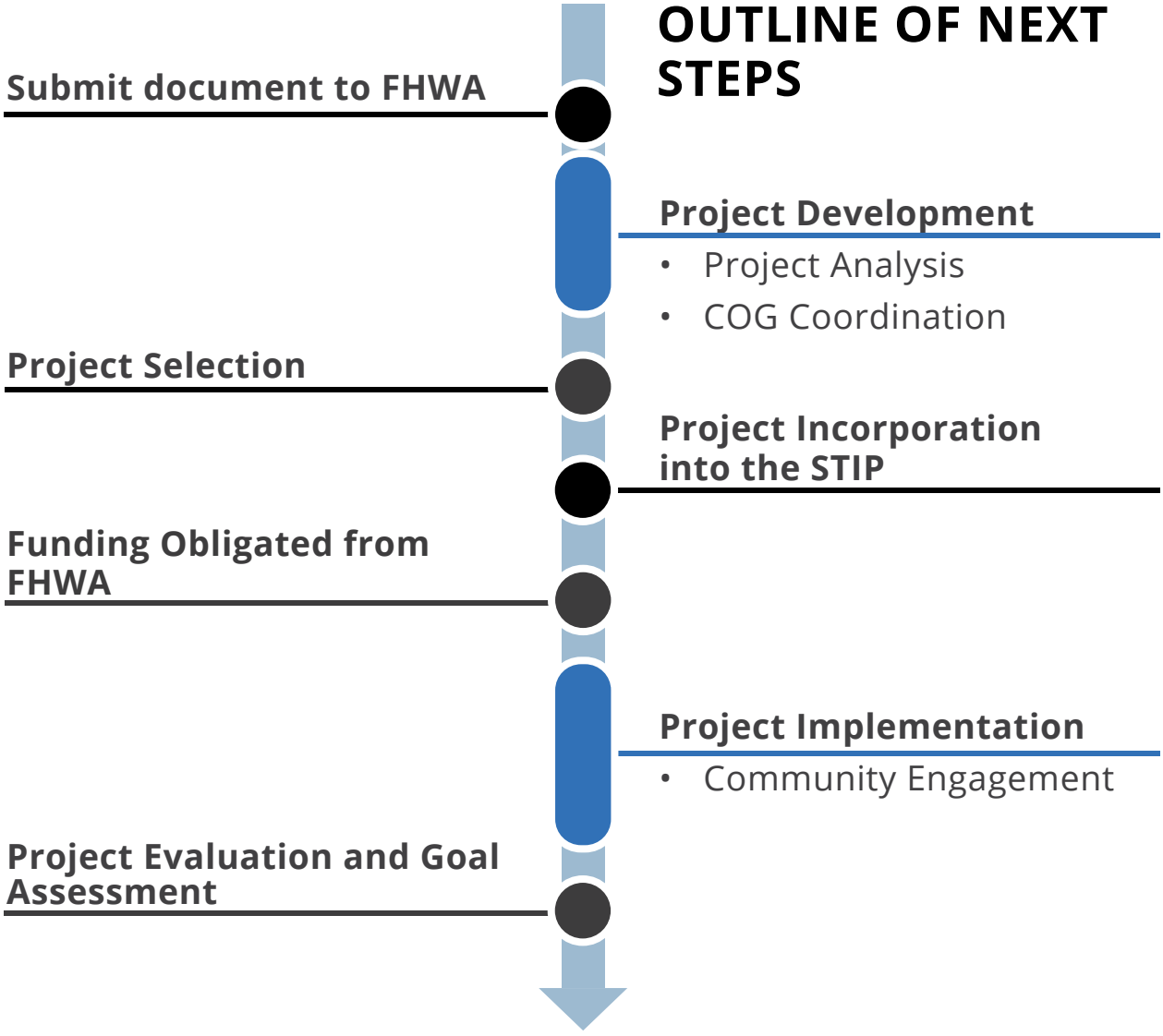


Figure 4.1: Solar installations will take advantage of potentially underutilized space.

4.1 Project Selection

This CRS provides a list of potential strategies for CTDOT to pursue. The strategies have been vetted with the COGs and run through a two-step analysis process. Many of the listed strategies are broad. In order to develop specific projects under these broad strategies, coordination between CTDOT, the COGs, and community partners will take place.

As projects are being developed, their potential benefits and costs will be evaluated. This project analysis will provide a closer examination, including a quantification, where possible, of Connecticut's Strategy Prioritization Factors. The Strategy Prioritization Factors themselves may be refined to provide a more specific view of the benefits stemming from a potential project. Following the Justice40 Initiative and the Community Benefits Prioritization Factor (which looks at whether a strategy could advance equity), underserved communities will be identified, and community members will be given a chance to provide feedback. Safety, sustainability, and accessibility – key focus points for CTDOT – will specifically be examined. This process will enable the further development of projects.

Outside of the development of projects, the CRS itself may be iterated upon. The CRS is to be updated at least once every four years. As this document is updated, CTDOT may examine the factors being considered in both analyses to determine how this work may best serve the goals of the CRP and the residents of Connecticut.

4.2 Solar in ROW

Following the evaluation performed of all ROW area provided, CTDOT may further develop concept plans for the potential suitable solar sites. Concept plans for these sites would be developed with PV design software for canopy or ground mount systems. The PV design analysis will provide more accurate electrical output of a solar energy generation system on the site. With this additional information known about the site, a preliminary construction estimate could be developed to determine project costs. Site specific challenges in grading or screening, and cost of installing the necessary utility interconnection, can also be incorporated.

Depending on the site, electrical interconnection could be "behind the meter" to serve the facility or direct connect to the grid. Once a solar layout is designed and system size is established, coordination with the local utility provider to confirm interconnection points and when grid connection should also occur. Programs such as remote net metering or the Non-Residential Renewable Energy Solutions (NRES) Program would also be evaluated at this step.

4.3 Development of a Program Evaluation Approach

The White House Office of Management and Budget (OMB) Circular A-11, Part 6 Section 200[15] notes five different kinds of evaluation: impact evaluation, outcome evaluation, process or implementation evaluation, formative evaluation, and descriptive studies. CTDOT will undertake one or more of these evaluation methods to measure the result of its CRP.

Project evaluation would allow CTDOT to understand whether funded projects are meeting the anticipated outcomes or if a project is achieving other, unanticipated but similarly critical outcomes. For example, a project that installs bicycle racks at a local school may spur community benefits such as classes for adults on how to ride a bike, or pop-up bicycle repair training programs. There are many ways of measuring a project's outcomes, some quantitative and some qualitative. Ways of measuring could include traffic counts and surveys to determine mode shift and vehicle movement for traffic flow, Complete Streets, and transit projects. Surveys could help identify any behavioral change as well as the public's satisfaction with the investments.

Program evaluation would determine whether funded projects have assisted in lowering GHG emissions and VMT. These two metrics are critical both from the CRP funding source as well as for CTDOT to meet its targets under EO 1 and EO 21-3. Successful CRP projects such as solar installations in the ROW, converting to LED lighting, and the purchase of electric vehicles for both the CTDOT fleet and transit fleet would contribute towards achieving these targets. An updated GHG emissions inventory within future Carbon Reduction Strategies would allow CTDOT to track its overall emission reduction progress.

Figure 4.2: East Rock Road Bridge over the Mill River in New Haven.

APPENDIX A

63-703 Exit Relocation and Widening) and 159-191 (Bridge Resurfacing and Safety Improvements) ICE Breakdown

	63-703 RESULTS (MT CO_2E)		159-191 RESULTS (MT CO_2E)	
ASPECT	LIFETIME (20 YEARS)	ANNUALIZED	LIFETIME (20 YEARS)	ANNUALIZED
Materials	9,060	453	765	38
Transportation	434	22	88	4
Construction	3,109	155	71	4
O&M	6,751	338	3,048	152
Usage	1,174,526	58,726	0	0
Total	**1,193,882**	**59,694**	**3,972**	**199**

	63-703 RESULTS (MT CO_2E)		159-191 RESULTS (MT CO_2E)	
INFRASTRUCTURE TYPE	LIFETIME (20 YEARS)	ANNUALIZED	LIFETIME (20 YEARS)	ANNUALIZED
Bridges and Overpasses	8,842	442	0	0
Culverts	295	15	0	0
Lighting	1,639	82	1,075	54
Roadways	8,417	421	2,707	135
Signage	163	8	190	9
Vehicle Operations	1,174,526	58,726	0	0
Total	**1,193,882**	**59,694**	**3,972**	**199**

APPENDIX B

Prioritization and Weighting of Existing Strategies

STRATEGY	TOTAL SCORE	TIME TO IMPLEMENT	EXISTING COMMUNITY SUPPORT	INCREASES SAFETY	INCREASES SYSTEM RELIABILITY	COST EFFECTIVENESS	EMISSIONS REDUCTION POTENTIAL	COST EFFECTIVENESS	COMMUNITY BENEFITS (+1 FOR EQUITY)	EXISTING COMMUNITY SUPPORT	INCREASES SAFETY	INCREASES SYSTEM RELIABILITY	COST EFFECTIVENESS	COMMUNITY BENEFITS
Complete Streets	**37**	medium	2	2	2	2	2	1	3	8	6	5	3	15
Transportation alternatives	**37**	medium	2	2	2	2	2	1	3	8	6	5	3	15
Bus rapid transit (CTfastrak)	**34**	long	2	1	2	1	1	1	3	8	3	5	3	15
Coordinated traffic system	**31**	medium	1	2	2	2	1	2	2	4	6	5	6	10
Bus electrification	**29**	short	2	0	0	2	1	2	3	8	0	0	6	15
Roundabout projects	**28**	medium	1	2	0	2	2	1	3	4	6	0	3	15
CMAQ projects	**25**	medium	1	0	0	2	1	2	3	4	0	0	6	15
EV fleet charging	**13.5**	medium	1	0	0	3	2	1.5	1	4	0	0	4.5	5
Pollinator habitat restoration	**9.5**	medium	0	0	0	3	2	1.5	1	0	0	0	4.5	5
Transition ICE to EV	**9.5**	short	0	0	0	3	2	1.5	1	0	0	0	4.5	5
Highway lighting to LED	**6**	medium	0	1	0	2	2	1	0	0	3	0	3	0

Prioritization and Weighting of Proposed Strategies

STRATEGY	TOTAL SCORE	TIME TO IMPLEMENT	EXISTING COMMUNITY SUPPORT	INCREASES SAFETY	INCREASES SYSTEM RELIABILITY	COST EFFECTIVENESS	EMISSIONS REDUCTION POTENTIAL	COST EFFECTIVENESS	COMMUNITY BENEFITS (+1 FOR EQUITY)	EXISTING COMMUNITY SUPPORT	INCREASES SAFETY	INCREASES SYSTEM RELIABILITY	COST EFFECTIVENESS	COMMUNITY BENEFITS
Safe Routes to School Infrastructure Improvements	**38.5**	medium	2	2	2	3	2	1.5	3	8	6	5	4.5	15
Ped/bike enhancements	**37**	medium	2	2	2	2	2	1	3	8	6	5	3	15
Transit access improvements (e.g. sidewalks)	**37**	medium	2	2	2	2	2	1	3	8	6	5	3	15
Transit software improvements	**37**	medium	2	0	2	3	1	3	3	8	0	5	9	15
E-bike chargers and lockers	**32.5**	short	2	0	2	3	2	1.5	3	8	0	5	4.5	15
BRT light	**31**	long	2	0	2	1	1	1	3	8	0	5	3	15
Rail transit improvements	**31**	long	2	0	2	1	1	1	3	8	0	5	3	15
TOD at CTDOT properties	**27.5**	long	1	1	1	1	1	1	3	4	3	2.5	3	15
Data for CTrides program	**22**	short	0	0	1	3	2	1.5	3	0	0	2.5	4.5	15
Solar in ROW	**21**	long	2	0	0	1	1	1	2	8	0	0	3	10
Sustainability rating system pilot project	**16**	short	0	1	0	2	2	1	2	0	3	0	3	10
Sustainable construction	**16**	long	0	0	0	2	1	2	2	0	0	0	6	10
Electric maintenance equipment	**9.5**	short	0	0	0	3	2	1.5	1	0	0	0	4.5	5
Consolidation of CTDOT facilities	**8**	medium	0	0	0	2	2	1	1	0	0	0	3	5

APPENDIX C

Potential Solar Analysis Site Breakdown

#	TOWN	HIGHWAY	MILEPOST	TOTAL AREA (ACRES)	CANOPY SITE AREA (ACRES)	ROOFTOP AREA (ACRES)	GROUND MOUNT AREA (ACRES)	ESTIMATED OUTPUT (MW)	SITE CLASS
1	Darien	I-95	12	1.7	1.3	0.4		0.53	MIXED
2	Westport	I-95	17	1.5	0.9		0.6	0.48	MIXED
3	Fairfield	I-95	21	2.2	1.7	0.5		0.66	MIXED
4	Trumbull	I-95	30	1.4	1.4			0.62	MIXED
5	Danbury	I-84	2	10.2	6.4		3.8	0.75	CANOPY
6	New Haven	I-95	44	3.6			3.6	0.72	GROUND MOUNT
7	New Haven	I-95	46	6.2			6.2	1.24	GROUND MOUNT
8	Milford	I-95	40	2.7	2.0	0.7		0.76	MIXED
9	Branford	I-95	63	1.6	1.2	0.4		0.45	MIXED
10	Guilford	I-95	58	1.4	1.2		0.2	0.35	MIXED
11	Madison	I-95	61	4.6	1.6	0.4	2.6	1.21	MIXED
12	New London	I-95	83	10.5			10.5	2.10	GROUND MOUNT
13	Norwich	I-395	11	3.2			3.2	0.64	GROUND MOUNT
14	North Stonington	I-95	92	6.5	6.5			1.18	CANOPY
15	Meriden	ROUTE 691	8	3.0	0.9		2.1	0.62	MIXED
16	Middletown	ROUTE 91	19	3.5	3.5			0.40	CANOPY
17	Mansfield	ROUTE 6	91	1.6	1.6			0.60	CANOPY
18	Griswold	I-395	22	3.6	0.7		2.9	0.79	MIXED

#	TOWN	HIGHWAY	MILEPOST	TOTAL AREA (ACRES)	CANOPY SITE AREA (ACRES)	ROOFTOP AREA (ACRES)	GROUND MOUNT AREA (ACRES)	ESTIMATED OUTPUT (MW)	SITE CLASS
19	Lisbon	I-395	21	2.2			2.2	0.44	GROUND MOUNT
20	Windsor	I-91	37	9.4	2.9		6.5	1.79	MIXED
21	Manchester	ROUTE 15	61	5.9	5.9			1.94	CANOPY
22	Enfield	I-91	47	6.4			6.4	1.28	GROUND MOUNT
23	Vernon	ROUTE 15	64	4.2			4.2	0.84	GROUND MOUNT
24	Willington	ROUTE 15	69	3.7	1.8		1.9	0.79	MIXED
25	Shelton	ROUTE 8	10	2.9			2.9	0.58	GROUND MOUNT
26	Danbury	I-84	7	5.1			5.1	1.02	GROUND MOUNT
27	Cheshire	I-691	3	2.6			2.6	0.52	GROUND MOUNT
28	North Haven	ROUTE 15	63	1.8			1.8	0.36	GROUND MOUNT
29	North Haven	I-91	12	1.8			1.8	0.36	GROUND MOUNT
30	West Hartford	I-84	42	2.6			2.6	0.52	GROUND MOUNT
31	East Hartford	ROUTE 15	58	4.0	2.5		1.5	0.30	GROUND MOUNT
32	Clinton	I-95	68	1.9	1.1		0.8	0.51	MIXED
33	Bridgeport	ROUTE 25	5	2.1			2.1	0.42	GROUND MOUNT
34	Westbrook	I-95	73	2.0			2.0	0.53	MIXED
35	Salem	ROUTE 11	0	12.2			12.2	2.44	GROUND MOUNT

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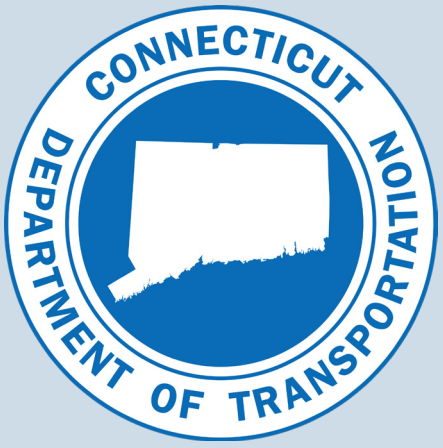

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