Technical Appendix: description of methods for projecting greenhouse gas reductions and benefits

We projected the greenhouse gas reductions that will result from the implementation of our proposed measures with assistance from the Northeast States for Coordinated Air Use Management (NESCAUM), and their subcontractor Sonoma Technologies (STI; for measures related to vehicle incentives and reducing idling) and Abt Associates (for waste enforcement and diversion measures). We also contracted directly with Synapse Energy Economics, Inc. to support the analyses related to removing health and safety barriers and expanding energy efficiency programs in the buildings sector.

MEDIUM AND HEAVY-DUTY ZERO EMISSION VEHICLES INCENTIVE PROGRAMS
We used EPA's MOtor Vehicle Emission Simulator (MOVES4; version 4) to estimate per mile CO2e, NOx, VOC, and $PM_{2.5}$ emissions in grams/MMBtu that will result from the proposed medium- and heavy-duty vehicle incentives. We defined "medium duty" as vehicles between 8,500 and 26,000 pounds GVWR (classes 2-6) and "heavy duty" as vehicles above 26,000 pounds GVWR (classes 7-8). We developed emissions inventories for medium- and heavy-duty vehicles specific to Connecticut for the calendar years 2025-2050 using the MOVES4 model. We calculated the number of ZEV purchases that could be incentivized through the program based on proposed funding level for medium- and heavy-duty ZEV incentives assuming we will provide 67% of incentives for medium-duty ZEVs and 33 for heavy-duty ZEVs. Based on the estimation of new ZEV VMT that would occur as a result of the ZEV incentives, we reduced VMT from internal combustion engine (ICE) vehicles in each calendar year between 2025 and 2050. We then projected emissions reductions by applying estimated ICE VMT reductions to the MOVES4 emissions estimates.

We projected the GHG and co-pollutant emissions reductions of 400 chargers assuming the following mix of charger power levels: 16% 150 kW, 80% 350 kW, and 4% 1,000 kW. This is equivalent to approximately 64 (sixty-four) 150 kW, 320 (three hundred and twenty) 350 kW, and 16 (sixteen) 1,000 kW chargers installed across Connecticut, based on the requested funds and a review of costs. We calculated charger power demand for MHD ZEVs using the nominal capacity of the chargers and assumed utilization rates of 30% for medium-duty vehicles, which typically operate locally, and 30% for heavy-duty vehicles based on the International Council on Clean Transportation report "Total Cost of Ownership of Alternative Technologies for Class 8 Trucks" and other studies. We converted the displaced VMT from diesel using the MOVES4 emission rates for each class of vehicle. We assumed that chargers installed as part of this program will, with maintenance, remain in service through 2050.

STI developed a tool that synthesizes these data to calculate vehicle incentive-related emissions reductions and MHD ZEV charger-related emissions reductions. Additional assumptions behind this tool's calculations are discussed below.

Measure implementation assumptions:
To quantify emissions reductions for this measure, we assumed the following:

- We will allocate funding as 67% for MD ZEV and 33% for HDV ZEV incentives.
- One-quarter of the vehicles will be introduced into the fleet in each calendar year beginning in 2026, totaling 290 medium-duty vehicles and 114 heavy-duty ZEVs by the end of 2029.
- MD ZEV incentives will average $138,750 per vehicle.
- HD ZEV incentives will average $174,349 per vehicle.

- We assumed that ZEVs have a 15-year lifespan: vehicles introduced in 2025 will be retired in 2040. We assumed that vehicles introduced in 2026 leave the fleet in 2041, and so on, such that by 2050, all ZEVs that resulted from this program will be retired.
- Tailpipe emissions for ZEVs are zero and we used emission factors from MOVES for ICE vehicles.
- We assumed a phase-in for charger installation between 2025 and 2030.
- Based on ICCT studies, we assumed that Level 3 150 kW cost $90,000, Level 3 350 kW cost $215,000, and 1 MW chargers cost $380,000.
- We calculated average power demand and associated grid emissions assuming charger utilization rates of 30% for MDVs and 30% for HDVs.

Reference case scenario:
The reference case for this scenario is that the EV charger mix described in this section is not installed and no new program is implemented to provide incentives for the purchase of medium- and heavy-duty zero-emission vehicles.

IDLE REDUCTION FOR THE CT DOT CRASH UNIT
We projected the idle emissions of exhaust for the 144 short-haul single-unit trucks (source type 52) that comprise Connecticut DOT's crash unit. We used EPA's MOVES4 (version 4) at Project Scale to estimate idle emissions of CO_2e, NO_x, SO_2, VOCs, and $PM_{2.5}$ exhaust. We used MOVES to generate an idle emissions rate in grams per hour that is applicable to truck-mounted attenuators (TMAs). We used information on the number of TMAs and their idle activity to project annual reductions in CO_2e and co-pollutant emissions from idle reduction technology. We also ran MOVES with the scale set to Default to estimate the trend in co-pollutant running emissions rates over time.

Measure implementation assumptions:
To quantify emissions reductions for this measure, we assumed the following:

- 144 TMAs are equipped with idle reduction technology between 2025 and 2030, at a rate of 24 installations per year for a five-year phase in and units operate for 13 years in service.
- Operation and maintenance costs will be reduced since idling of diesel trucks uses approximately one gallon of fuel per hour and results in increased needs for maintenance.
- We estimated that TMAs idle 2,096 hours per vehicle over 262 days per year, totaling 301,824 truck idling hours per year for MOVES4 regulatory class 46 vehicles.

Modeling assumptions:
The following key assumptions about emission reductions were used to quantify emission reductions for this measure:

- We modeled normal idling activity, as MOVES does not permit modeling of extended idle for source type 52 trucks.
- CO_2e rates do not change over time, since they are almost entirely based on fuel consumption rates.

Reference case scenario:
The reference case for this scenario is that Connecticut DOT's crash unit does not use idle reduction technology, resulting diesel fuel combustion (e.g., 1.5 million gallons between 2025 and 2030).

EXPANSION OF HEALTH AND SAFETY BARRIERS PROGRAM AND ENERGY EFFICIENCY PROGRAMS

We projected per-household emissions reductions that would result from the proposed measure using the Building Decarbonization Calculator (BDC) from Synapse Energy Economics, Inc. and historical reporting data from the Residential Energy Preparation Services program (REPS), CTDEEP's income eligible pathway for energy efficiency programs, HES-IE, and energy efficiency programs under CTDEEP's C&LM plan. We quantified the average historical per-household energy use savings by primary heating fuel type for REPS participants and estimated the mix of equipment, fuel types, and associated heating efficiencies in future participating households. We calculated average emission reductions per participating household by weighting the energy savings according to primary heating fuel type of existing building stock then multiplying by the corresponding emissions factors. We quantified the average annual historical energy use savings by fuel type for the full portfolio of existing C&LM programs per dollar spent. We then projected the cumulative emissions reductions over time, assuming annual spending for this measure of $16 million per year between 2025 and 2029.

To quantify CAP and HAP emissions reductions, we multiplied the fuel savings by emissions factors for combustion equipment from EPA's AP-42 and WebFIRE database. We selected emission factors specific to the sector, end-use equipment, and fuel type. We did not account for changes in CAP or HAP emissions from electricity consumption.

We used historical REPs, HES-IE, and C&LM program data as inputs for the Building Decarbonization Calculator (BDC). The BDC is an in-house tool developed by Synapse Energy Economics used for modeling the energy consumption of major building end-uses, including space and water heating, in residential and commercial buildings throughout the United States.

To avoid the potential for double counting between REPS, which addresses barriers to weatherization, and our energy efficiency programs through C&LM, we properly allocated the costs and GHG savings associated with HES-IE, our income-eligible energy efficiency pathway, using the following approach:

1) We calculated the number of homes that can be remediated with the proposed funding level for REPS.
2) We calculated the expenditures from our C&LM energy efficiency programs needed to serve the number of homes identified in step 1 using costs from the HES-IE program.
3) We subtracted the total of expenditures from step 2 (REPS-related spending through HES-IE) from the proposed funding level available for expanded energy efficiency programs.

These steps reduce the effective budget and GHG savings to non-REPS participants from C&LM energy efficiency programs to provide an appropriate accounting of the GHG reductions unlocked by REPS.

Measure implementation assumptions:

To quantify emissions reductions for this measure, we assumed the following:

- All low income households with health and safety barriers to weatherization are eligible.
- Per-household energy savings from REPS participation are equal to average historical per-household energy savings from participation in REPS and HES-IE.
- The cost to prepare a household for weatherization is $11,070 (2023 dollars), based on historical REPS program data.

- Measure lifetimes are based on reported lifetime savings divided by reported annual savings for the HES-IE program. Measure lifetimes vary by equipment fuel type: 20.3 years for natural gas, 21.1 years for fuel oil, 21.7 for propane, and 8.1 for electricity. These values include air sealing and insulation (all weatherization measures combined).
- Investor-owned utilities' customers in Connecticut are eligible to participate in C&LM.
- Energy use savings from participation are equal to average historical energy use savings for C&LM.
- Measure lifetimes are based on reported lifetime energy savings divided by annual energy savings by fuel type. Measure lifetimes vary by fuel type: 13.9 years for natural gas, 20.4 years for fuel oil, 17.1 for propane, and 9.5 for electricity.

Table 1. Assumed spending by year for the proposed funding level

	Program	
Year	REPS	C&LM
2025	12%	25%
2026	22%	25%
2027	33%	20%
2028	22%	20%
2029	11%	10%

Modeling assumptions:
We used the following modeling assumptions to quantify emission reductions for this measure:

- Emissions rates for fuel oil decline over time due to increased biofuel blending. We assume the statutory minimum for biofuel blending levels: starting with 5%, increasing to 10% in 2025, 15% in 2030, 20% in 2034, and 50% in 2035 onwards.
- GHG emissions factors for combustion fuels are based on the EPA's 2023 EPA Emissions Factors Hub. We converted emissions into metric tons of CO2-equivalent using GWPs from the IPCC 5th Assessment report.
- Electric emissions factors for 2024-2039 were forecasted based on modeling done for CTDEEP's Integrated Resources Plan published in 2020.[14] Electric emissions factors after 2040 are assumed to be zero, as statute requires Connecticut to achieve a zero-carbon grid by that year.
- Criteria and hazardous air pollutant emissions factors for combustion fuels are based on EPA's AP-42: Compilation of Air Pollutant Emissions Factors from Stationary Sources[16] and EPA's WebFIRE database.

Reference case scenario:
In the reference scenarios for REPS and C&LM, the number of households that participate in REPs is constrained by non-CPRG funding levels. We assume, therefore, that in absence of CPRG funding, no additional households achieve weatherization-related energy savings and no additional buildings (beyond those that would already participate) will achieve energy savings.

Measure-specific activity data and implementation tracking metrics:
The table below summarizes key activity data used to project and track emissions reductions for greenhouse gases, criteria air pollutants, and hazardous air pollutants.

Table 2. Key activity data and values used for modeling for REPS

Metric	Units	Value
Annual energy savings, 2030		
Fuel oil	Btu, billion	3
Natural gas	Btu, billion	4
Propane	Btu, billion	0
Wood	Btu, billion	0
Electricity	Btu, billion	2
Cumulative energy savings, 2025-2030		
Fuel oil	Btu, billion	11
Natural gas	Btu, billion	16
Propane	Btu, billion	1
Wood	Btu, billion	0
Electricity	Btu, billion	7
Cumulative energy savings, 2025-2050		
Fuel oil	Btu, billion	61
Natural gas	Btu, billion	85
Propane	Btu, billion	7
Wood	Btu, billion	0
Electricity	Btu, billion	15

Table 3. Key activity data and values used for modeling for C&LM

Metric	Units	Value used for modeling
Annual energy savings, 2030		
Fuel oil	Btu, billion	5
Natural gas	Btu, billion	17
Propane	Btu, billion	1
Wood	Btu, billion	0
Electricity	Btu, billion	25
Cumulative energy savings, 2025-2030		
Fuel oil	Btu, billion	23
Natural gas	Btu, billion	72
Propane	Btu, billion	5
Wood	Btu, billion	0
Electricity	Btu, billion	104
Cumulative energy savings, 2025-2050		
Fuel oil	Btu, billion	112
Natural gas	Btu, billion	238
Propane	Btu, billion	22
Wood	Btu, billion	0
Electricity	Btu, billion	245

FOOD WASTE DIVERSION
We used EPA's Solid Waste Emissions Estimation Tool (SWEET) model to project source-level emissions from the solid waste sector to compare enforcement and food scraps diversion scenarios (SWEET_Version4.0.3_CT) to a business-as-usual scenario (SWEET_Version4.0.3_CT_Baseline).

Measure implementation assumptions:

	Estimated tons of food waste diverted						
Climate action	**Year 1**	**Year2**	**Year 3**	**Year 4**	**Year 5 (and each year going forward)**	**Total Tons 2025-2030**	**Total Tons 2025-2050**
Commercial Organics Law Enforcement	19,637.8	39,275.6	58,913.4	78,551.2	98,189.0	294,567	2,258,347
Diversion Programs for Municipalities	3,202.4	6,404.8	9,607.2	12,809.6	16,012.0	48,036	368,276

The estimated tons of food waste diverted from increasing enforcement to CT's Commercial Organics Law is based on the annual tonnage from CT generators identified on EPA's Excess Food Opportunity Map. Potential generators were filtered by those whose high-end estimates of excess food exceeded 26 tons per year, totaling 1256 generators. We obtained the estimate of 98,189 tons per year by summing the low-end estimated tonnage of excess food produced by such generators. We estimated yearly food waste that will be diverted by assuming the program will reach one fifth of generators annually. We estimated the tons of food waste that will be diverted from municipal programs using the average percent of available food diverted from disposal per household during CT's Sustainable Materials Management grant program, assuming an equivalent participation rate.

Modeling assumptions:
Assumptions for the emissions reduction modeling are listed in Table 4. Because SWEET does not have the ability to account for food scraps diverted to animal feed, an additional calculation was performed to remove the tonnage of waste diverted to animal feed entirely from the waste stream. To complete this, we changed the *Per capita waste generation rate inside formal collection zones* from 2.000 to 1.999, as shown in Table 4. SWEET uses this variable to estimate the total tons of waste collected. By slightly reducing this variable, the estimated tons of waste collected decreased by 3,873 tons, which is the total amount of food waste that was diverted to animal feed in 2022. This adjustment simulates the diversion of 3,873 tons of food waste to animal feed.

Table 4. Assumptions for modeling greenhouse gas reductions for food scraps diversion

Input	Value	Justification
Per capita waste generation rate inside formal collection zones *(Business-as-Usual Case)*	2.000 (kg/capita/day)	SWEET uses a default value of 2.630 for North America based on the 2019 Refinement to the 2006 IPPC Guidelines for National Greenhouse Gas Inventories. The value was decreased to better reflect Connecticut's waste collection data as the original default value was overestimating waste generated.

Per capita waste generation rate inside formal collection zones *(Alternative Scenarios)*	1.999 (kg/capita/day)	Reduced to account for food scraps to animal feed
Average annual percent growth rate in the quantity of waste collected – historical and projected future	0 percent	The amount of solid waste collected over the past several years has remained constant and can be assumed to remain constant in the future.
Percentage of waste generated inside formal collection zones that is collected	100 percent	It is assumed that all waste is generated within the state of Connecticut is collected.

Reference case scenario:
In 2022, CTDEEP reported 488,012 tons of food scraps in the waste stream. Of that, 26,030 tons – about 5 percent – were diverted. The diverted tonnages went to three destinations:

- Anaerobic digestion with beneficial reuse (79.56 percent)
- Animal feed technology (14.88 percent)
- Composting (5.56 percent)

Measure-specific activity data and implementation tracking metrics:
We used state-level estimates, including:

- *2022 MSW Quarterly Disposal data,* which details the quarterly tonnage of MSW sent to each in-state and out-of-state disposal facility,
- *2022 MSW Diversion Activity data*, which details the tonnage of materials diverted by type and pathway,
- *Waste characterization estimates by waste stream components from 2015*, which was applied to estimate the 2022 disposal tonnage of food waste, and
- *Various diversion scenarios* of the percentage of food scraps that could be diverted from disposal either through anaerobic digestion, composting, or animal feed technology. Due to expected food waste processing capacity, 51.8% of food waste was estimated to be processed at anaerobic digestion facilities, 46.2% was estimated to be processed at composting facilities, and 2% was estimated to be diverted to animal feed.

Table 5. Summary of the data used as inputs for SWEET.

Input	BAU Value	Notes
Tons of waste diverted – waste combustion	1,617,253 tons	Sum of waste to Resource Recovery Facility
Tons of waste diverted – composting	1,446 tons	
Tons of waste diverted – anaerobic digestion	20,710 tons	
Tons of waste disposed – landfills	571,142 tons	Sum of waste to Landfill

SWEET also requires additional activity data to complete the analysis. Table 6 shows additional data inputs that were used in the analysis.

Table 6. Additional activity data for SWEET modeling

Input	Value	Source
Population in formal collection zones	3,608,706	US Census Population Estimates, July 1, 2022, (V2022)
Average annual precipitation	43.79 in.	Statista (2022)
Mean annual temperature	49.9°F	NOAA National Centers for Environmental Information (2022)

IDENTIFYING AFFECTED LOW-INCOME AND DISADVANTAGED COMMUNITIES

All measures in this application are statewide and are expected to benefit all LIDACs in Connecticut. A list of census block groups with their respective Council of Governments and municipality is attached to this application as Areas_CTDEEP.xlsx. We used EPA's dataset available at https://ejscreen.epa.gov/mapper/ to identify Connecticut census block groups that meet EPA's definition of low-income and disadvantaged communities (LIDACs) of: any census tract that is included as disadvantaged in CEJST; any census block group at or above the 90th percentile for any of EJScreen's Supplemental Indexes when compared to the nation or state; and/or any geographic area within Tribal lands, as included in EJScreen.

Census block groups	**CT**	2,716
	LIDACs	833
Population (2023)	**CT**	3,611,317
	LIDACs	1,169,336 *(32% of CT's total population)*

LOW-INCOME AND DISADVANTAGED COMMUNITIES BENEFITS ANALYSIS

Health Effects Impacts of Reductions on Air Pollution Concentration - To estimate the economic value of the health benefits associated with the proposed measures, we used EPA's CO-Benefits Risks Assessment (COBRA) screening model. All scenarios used 2023 as analysis year for population, baseline health incidence, baseline emissions and health impact valuations datasets. See attachment *GHGcalcs_CTDEEP.xlsx* for reductions of co-pollutants and associated COBRA outputs per each measure. The yearly COBRA outputs were multiplied by 5 to consider a 5-year period of performance. In addition, these values were apportioned to 32% to calculate benefits to LIDACs in Connecticut. The scenarios were built for Connecticut with the following input sectors per measure:

(1) Medium and Heavy-duty Zero Emissions Vehicles Incentive and Charging – Sector: *Highway vehicles > Subsector: Diesel fuel > Subsector: Heavy duty.*
(2) Idle Reduction for the CTDOT Crash Unit – Sector: *Highway vehicles > Subsector: Diesel fuel > Subsector: All subsectors.*
(3) Expansion of Health and Safety Barriers Program and Energy Efficiency Programs – Sector: *Fuel combustion: Other* > Subsector: *Residential Other* > Subsector: *All subsectors*.

Estimates of Jobs Created – Several studies provide the basis for jobs created per each measure. CTDEEP estimates that a total of 723 jobs would be created with the implementation of the proposed measures. To apportion job benefits to LIDACs, we use the Justice40 goal of 40% benefits allocated to LIDACs. This is different than the 32% of total population used for health benefits as we assume that jobs are not distributed equally across the population like health benefits from reducing co-pollutants.

(1) Medium and Heavy-duty Zero Emissions Vehicles Incentive and Charging

Assumption: 12 jobs created for every $1 million dollar invested in charging infrastructure (*IEA Sustainable Recovery Report* 2020; *Zero Emissions Transportation Association* 2022)

- $4 million invested in charging infrastructure * 12 jobs created = <u>48 full-time jobs in CT</u>
- 40% of jobs reserved to LIDACs = <u>19.2 jobs in LIDACs</u>

(2) Idle Reduction for the CTDOT Crash Unit

Assumption: 4 hours of installation per idle reduction system (Laughlin, Michael, and Owens, Russell J. *Case Study – Idling Reduction Technologies for Emergency Service Vehicles*. United States: N. p., 2016. Web. https://doi.org/10.2172/1245195)

- 144 installed idle reduction systems * 4 labor hours = <u>576 labor hours in 5 years (120 workdays)</u>
- 40% of labor hours reserved to LIDACs = <u>230 hours in LIDACs (28.75 workdays)</u>

(3) Expansion of Health and Safety Barriers Program and Energy Efficiency Programs

Assumption: 10.6 jobs created with every $1 million invested in energy efficiency (Garret-Peltier, Heidi. 2017. *Green versus brown: Comparing the employment impacts of energy efficiency, renewable energy, and fossil fuels using an input-output model*. *Economic Modelling* 61. https://doi.org/10.1016/j.econmod.2016.11.012)

- $19 million invested * 10.6 jobs created = <u>201 jobs in 5 years</u>
- 40% jobs reserved to LIDACs = <u>80 jobs in LIDACs</u>

(4) Food Waste Diversion

Assumption: 13 jobs created with each 10,000 tons of waste diverted per year (The Institute for Local Self Reliance. *Pay Dirt, Composting in Maryland to Reduce Waste, Create Jobs, and Protect the Bay*. May 2013. https://ilsr.org/paydirt/)

- 368,276 tons / 5 years = 73,655.20 tons/year = 7.34
- 7.34 * 13 jobs/year = 95.76 jobs/year
- 95.76 jobs/year * 5 years = <u>478.82 jobs in 5 years</u>
- 40% of jobs reserved to LIDACs = <u>191 jobs in LIDACs</u>