TECHNICAL APPENDIX

In alignment with the Notice of Funding Opportunity (NOFO), this Technical Appendix explains the methodology and assumptions used to quantify the GHG emission reductions and cost-effectiveness metrics for each measure in this application. An introduction to the overall approach is below, followed by descriptions of the GHG factors and measure-specific methodologies. Also note the GHG Emissions Reduction Calculations Spreadsheet has been provided. It contains annual GHG emissions profiles for each project as required by the NOFO. They are not repeated in this Appendix due to page length limits, as this application includes many projects, each with different annual emissions profiles year over year.

Note: Practical Energy Solutions, a division of Spotts, Stevens and McCoy, performed the GHG analysis and prepared the technical appendix for this application[1].

Overall Approach to GHG Calculations

This application includes shovel-ready projects that may include GHG emission-neutral components – such as GHG-saving net-zero high-performance rehabs and new construction projects that include non-GHG components such as interior upgrades, structural improvements, exterior repairs, and more. The Philadelphia Energy Authority (PEA) directed CPRG funding to the GHG measures themselves; that is, the portions of projects that reduce GHG emissions – such as high-efficiency HVAC, weatherization, and solar PV array installations. Thus, to calculate cost-effectiveness of the CPRG funding over the performance periods (2025-2030; 2025-2050), project budget is defined as the cost of these funded measures. For projects that impact GHG emissions in their entirety – such as solar PV with battery energy storage systems (BESS), electric vehicle (EV) charging station installations, and composting program expansions – the total project budget was applied to the cost-effectiveness metrics.

As required, this application quantifies emission reductions that will occur as a result of EPA's CPRG implementation grant funding. Where CPRG funding represents a fraction of the total funding for a GHG-reduction measure, total estimated $MTCO_2e$ reductions are scaled by the same fraction to quantify the emissions savings directly associated with CPRG funding. This application also includes a second cost-effectiveness metric for the reviewers' consideration, as per Sect 2, Part C of the Project Narrative. Project schedules were taken into account when calculating GHG emissions reductions; the year of project completion (or the "on-line" date) was defined as Year 1. We factored this into the GHG emissions calculations for each project and performance period; for example, for a project scheduled to finish Q4 2026, 2027 is Year 1 for GHG emissions accounting.

Common GHG Emissions Factors

For all projects, $MTCO_2e$ emissions of the reference (baseline) and post-project cases were calculated using a consistent set of factors and methodologies for all energy sources. All CO_2e emissions were quantified based on the energy source from the point of generation at the power plant (electricity) through local delivery/transmission (all sources) and on-site combustion (gas, fuel oil, propane). $MTCO_2e$ emissions were quantified in pounds for all projects using the most relevant and trusted data sources and were tailored to our region of the country whenever possible, since they can vary widely

[1] Practical Energy Solutions' (PES) focus is reducing energy consumption in government buildings, educational institutions, and commercial facilities in the Mid-Atlantic region. They grew from a company that performed operational assessments and energy audits of commercial buildings, to a company with a broad base of services for the energy sector. PES is part of SSM Group, Inc. providing a full range of engineering services, covering all municipal engineering services and more. Their staff of engineers, planners, geologists, surveyors and landscape architects integrate technologies with sound engineering judgment and experience to meet clients' needs.

from region to region. Aggregated MTCO2e emissions were converted to MTCO2e for all final GHG savings and cost-benefit metrics. GWP factors are from *IPCC AR5 Fifth Assessment Report (2013)* as required in the NOFO*.* For all fuel sources, the same GHG emissions factors were maintained through both performance periods, since it is not possible to predict how the emissions profile of any energy source will change over the next quarter century.

Electricity

Grid Electricity

All grid electricity consumption projections were converted to kWh for purposes of the emissions calculations. The CO_2, CH_4, and N_2O content of grid electricity was taken directly from the most current eGRID emissions data for the RFC East region (Table 1).[2]

Table 1. RFC East Grid Factors

CO_2	CH_4		N_2O	
lbs/kWh	lbs/kWh	GWP	lbs/kWh	GWP
0.657386	0.000045	28	0.000006	265

Calculation:

Pounds CO_2e per kWh = CO_2 lbs/kWh + (CH_4 lbs/kWh*CH_4 GWP) + (N_2O lbs/kWh*N_2O GWP)
= 0.657386 + (0.000045 * 28) + (0.000006 * 265)
= **0.660236 CO_2e lbs/kWh**

Prior to calculating the $MTCO_2e$ emissions equivalency of grid-based electricity for all reference scenarios/baselines and post-project consumption forecasts, a transmission and distribution (T&D) loss multiplier of ~1.03 (3%) was applied to the kWh load to account for these losses in our local grid.[3]

Calculation:

*Total kWh = Projected or actual kWh * T&D Loss Multiplier* (**1.03369081038726**)

Solar PV Electricity

Electricity generated by solar PV arrays is considered to produce zero GHG emissions, and no T&D loss multiplier was applied since solar PV electricity is net metered and consumed at the point of generation. For solar PV projects, project owners' projections of Year 1 annual kWh generation were used as the basis of the calculations, and Practical Energy Solutions (PES) validated the Year 1 projections against the kW/DC capacity of each project's PV system. Depending on the project, Year 1 solar PV generation estimates derived from use of the Helioscope Commercial Solar Software for PV Design runs, or from the professional solar PV installers and engineering firms that submitted project proposals.

Assumptions:

Degradation rate. To project solar PV array generation over time (Years 2-25), we applied a 0.5% annual degradation factor over a 25-year product lifespan. This is the industry standard, although degradation rates are variable and nonlinear depending on exposure and quality.[4]

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[2] U.S. EPA eGRID Subregion RFCE 2022 Data. egrid2022_data.xlsx (live.com)

[3] U.S. Energy Information Administration Independent Statistics and Analysis. Pennsylvania Electricity Profile 2022. Data Table #10, Line 26, "estimated losses." Pennsylvania Electricity Profile 2022 - U.S. Energy Information Administration (EIA)

[4] Jordan DC and Kurtz SR. National Renewable Energy Laboratory. Photovoltaic Degradation Rates – An Analytical Review. Photovoltaic Degradation Rates -- An Analytical Review: Preprint (nrel.gov)

- *Product lifespan*. While most solar PV arrays retain 80% of their original production after 30 years, 25 years is the accepted lifespan. This is when inverters and batteries often need replacement.[5]

Natural Gas

All gas quantities were converted to ccf for purposes of GHG emissions calculations. To ensure consistency with the electricity generation methodology (which accounts for T&D losses), a local distribution methane leak factor was applied to natural gas emissions by adding the national average leak rate to the per-ccf emissions profile (Table 2).

Table 2. Gas Factors[6,7,8]

CO_2	CH_4			N_2O	
lbs/ccf	lbs/ccf*	GWP	Local Distribution Leak Factor	lbs/ccf*	GWP
12.096	0.021424879	28	1.00281942842496	0.002142488	265

**Converted from source reference of g/mmBTU as follows:*

GHG	g/mmBTU	g/ccf	lbs/ccf*
CH4	1	9.71817298	0.021425
N2O	0.1	0.9718173	0.002142

**To convert grams to pounds: g/ccf * 0.00220462*

Calculation:

Lbs CO_2e per ccf = CO_2 lbs/ccf + (CH_4 lbs/ccf*CH_4 GWP*CH_4 Distribution Leak Factor) + (N_2O lbs/ccf*N_2O GWP)

= 12.096 + (0.021424897*28*1.00281942842496) + (0.002142488*265)

= **12.1196277722866 CO_2e lbs/ccf**

Other Fuels

Table 3 shows the factors used to calculate emissions per gallon for other fossil fuels. Local distribution loss factors were not applied for these fuels due to lack of readily available data.

Table 3. Fuel Oil and Propane Emissions Factors[3]

Fuel Source	CO_2	CH_4			N_2O		
	lbs/gal	g/gal	lbs/gal*	GWP	g/gal	lbs/gal*	GWP
Fuel Oil #6	24.78	0.45	0.000992079	28	0.09	0.000198416	265
Propane	12.68	0.27	0.000595247	28	0.05	0.000110231	265

**To convert grams to pounds: g/ccf * 0.00220462*

Calculations:

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[5] Deline C, Jordan D, Sekulic B, et al. National Renewable Energy Laboratory. PV Lifetime Project – 2021 NREL Annual Report. PV Lifetime Project - 2021 NREL Annual Report

[6] U.S. Energy Information Administration. Carbon Dioxide Emissions Coefficients. Release Date: September 7, 2023. U.S. Energy Information Administration - EIA - Independent Statistics and Analysis

[7] U.S. Environmental Protection Agency. Emission Factors for Greenhouse Gas Inventories. Last Modified: March 26, 2020. Emission Factors for Greenhouse Gas Inventories (epa.gov)

[8] U.S. Department of Energy. Fact Sheet: Natural Gas Greenhouse Gas Emissions. 20140729 DOE Fact sheet_Natural Gas GHG Emissions.pdf (energy.gov)

Lbs Fuel Oil #6 CO_2e per gallon

= CO_2 lbs/gal + (CH_4 lbs/gal*CH_4 GWP) + (N_2O lbs/gal*N_2O GWP)
= 24.78 + (0.00099207*28) + (0.000198416*265)
= **24.78119049 CO_2e lbs/gallon**

Lbs Propane CO_2e per gallon

= CO_2 lbs/gal + (CH_4 lbs/gal*CH_4 GWP) + (N_2O lbs/gal*N_2O GWP)
= 12.68 + (0.000595247*28) + (0.000110231*265)
= **12.68070548 CO_2e lbs/gallon**

GHG Emission Reductions Calculations by Measure

This implementation grant targets the following focus areas for GHG reductions, which are contained in the region's Priority Climate Action Plan (PCAP), led by the Delaware Valley Regional Planning Commission:

- Measure 1: Actions to Support Decarbonization of Local Government Operations
- Measure 2: Actions to Implement Energy Efficiency, Electrification, and Clean Energy for Residential Buildings
- Measure 3: Actions to Implement Energy Efficiency, Electrification, and Clean Energy for Commercial Buildings
- Measure 4: Actions to Transition Light Duty Vehicles to Low or No Carbon Emission Vehicles

Measure-specific documentation of GHG reduction calculations follows.

Measure 1: Actions to Support Decarbonization of Local Government Operations
Actions to support decarbonization of local government operations include shovel-ready projects across the following southeastern PA counties: Philadelphia, Delaware, Chester, Bucks, and Montgomery. Each project includes at least one, and often more than one, of the following scopes:

- Energy Efficiency & Electrification Retrofits in Existing Buildings for Deep Energy Reductions
- On-Site Solar PV Generation + Battery Storage for Clean Electricity Generation and Resiliency
- Net Zero All-Electric New Construction, for No-Added GHG Impacts
- EV Charging Stations to Accelerate Growth of Local Government EV Fleets
- Bus Electrification
- LED Pedestrian Streetlights
- Wastewater Treatment Biogas Purification/Flaring Reduction
- Community Composting Expansion Projects.

Energy Efficiency Retrofits Methodology
For energy efficiency retrofits in existing buildings, energy models and engineering estimates were provided by project owners and mechanical engineering subcontractors. PES reviewed these projections to ensure overall quality and accuracy and performed high-level internal modeling of reference case scenarios and project specifications for projects that required further quantification. This engineering oversight helped ensure accurate and consistent measurement of GHG savings.

For all internal modeling, a PES Licensed Professional Engineer (P.E.) performed Excel-based energy modeling using building type, square footage, operating hours, and reference-case and project-case mechanical system and building envelope efficiency specifications to quantify energy consumption by type (electricity, natural gas, fuel oil, propane) for reference and project cases. The reference case represented an existing building or, in the case of new construction, a "to-code" building with the year of construction taken into consideration. The models integrated ASHRAE standard design factors[9] and other industry standard references[10,11] as well as pump, fan motor, and lighting factors drawn from the firm's two decades of data collection and experience auditing and specifying energy-efficiency projects in our region. Individual project modeling spreadsheets and outputs are available upon request.

On-Site Solar PV Generation + Battery Storage
The solar PV GHG methodology has been previously noted. For all solar projects, avoided CO_2e emissions were calculated by subtracting the per-kWh solar PV GHG emissions (zero) from the grid-based electricity factor provided on pg. 2.

Net Zero All-Electric New Construction
For net-zero all-electric new construction, energy modeling was supplied by the project owner, and the PES P.E. performed an internal QC review as described earlier to help ensure the accurate capture of energy savings. Modeled electricity consumption was then offset by on-site solar PV generation, calculated as described on pg. 2.

EV Charging Stations for Fleets
Measure 1 projects include investments in EV charging networks for local government light-duty EV fleets. These investments are critical to not only growing EV fleets to capacity, but to keeping existing EV fleets running due to insufficient and aging existing EV infrastructure. Current annual EV fleet miles plus annual EV mileage growth projections based on the project owners' EV purchasing plans were applied over a 10-year lifespan of the EV charging stations. Savings were calculated based on average CO_2e emissions per mile for EVs vs. average CO_2e emissions per mile for comparable combustion vehicles.

Calculations:

Lbs CO_2e EV per mile	= lbs CO_2e per kWh * kWh per mile[12]
	= **0.660236** * 0.36
	= 0.23768496
Lbs CO_2e Combustion Vehicle per mile	= (lbs CO_2e per gallon gas)[13] / average light-duty miles per gallon[12]
	= (8,887 grams CO_2 * 0.00220462 pounds/gram * 1.025 non-CO_2e GHG factor) / 22.2
	= 0.904606729211712
Savings per mile EV vs Combustion	= Lbs CO_2e Combustion Vehicle per mile - Lbs CO_2e per mile
	= 0.904606729211712 - 0.23768496
	= **0.666921769211712**

<u>Assumptions:</u>

[9] American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 90.1-2022 – Energy Standard for Sites and Buildings Except Low-Rise Residential Buildings. Table 9.5.1, Tables G-B and G-E through G-O. Standard 90.1 (ashrae.org)

[10] Pennsylvania Public Utility Commission (PUC) Technical Reference Manual 6/2014. Technical Reference Manual | PA PUC

[11] Waltz James P. Computerized Building Energy Simulation Handbook. Computerized Building Energy Simulation Handbook: James P. Waltz: 9780881732597: Amazon.com: Books

[12] U.S. Environmental Protection Agency. Comparison: Your Car vs an Electric Vehicle. Comparison: Your Car vs. an Electric Vehicle | US EPA

[13] U.S. Environmental Protection Agency. Greenhouse Gas Emissions from a Typical Passenger Vehicle. Greenhouse Gas Emissions from a Typical Passenger Vehicle (EPA-420-F-14-040a, May 2014)

- 10-year lifespan for L2 charging stations. Estimates typically range between 8-12 years depending on usage, weather conditions, quality, and maintenance. After ten years of use, we no longer captured GHG savings because the chargers will require replacement.
- A mid-range 1.025 factor was applied to account for GHG emissions from gasoline combustion other than direct CO_2 emissions – including CH_4, N_2O, and air conditioning refrigerants. EPA reports it is difficult to estimate these emissions since they are dependent on the design of the engine and emission control system, not fuel consumption. EPA estimates 1%-5% of conventional combustion passenger car GHG tailpipe emissions derive from non-CO_2 sources.
- For one of Measure 1 projects, the L2 EV chargers will not be put into substantial fleet use immediately due to an ongoing EV fleet purchasing plan. However, these chargers will be put into immediate public use. We therefore applied the GHG emissions savings calculation methodology for public chargers to this project, as outlined under Measure 4, page 9.

Bus Electrification

GHG savings for electrification of City buses with installation of EV charging stations were calculated by converting current bus fleet miles to annual CO_2e emissions per conventional diesel bus vs. EV bus.

Calculation:

CO_2e Savings = Lbs CO_2e per Mile Conventional Diesel Bus – Lbs CO_2e per mile EV Bus

Lbs CO_2e per Mile Conventional Diesel Bus

*= (CO_2 lbs/gal + CH_4 CO_2e lbs/gal + N_2O CO_2e lbs/gal)/5 mpg – EV bus kWh/mile * CO_2e/kWh*

Lbs CO_2e per Mile EV Bus

*= (kWh per mile determined as: Full charge kWh for new-technology BEV battery/total miles equivalency) * lbs CO_2e per kWh*

= (520 kWh charge/310.7 miles equivalency)[14] * **0.660236**

<u>*Assumptions:*</u>

- Diesel fuel CO_2e emissions are derived from EPA sources.[15]
- Average mpg for a conventional diesel City bus was estimated to be 5 mpg (average in the city mpg bus range of 3.5-6.5 mpg).[16]

LED Pedestrian Streetlights

Calculations were provided through a detailed professional energy assessment which included a survey of existing lamp fixtures/types; creation of a baseline of electricity consumption based on lamp type/wattage, hours of operation, and existing utility bills; and simple kWh savings calculations resulting from the replacement of each existing fixture type with high-performance Selux or Cobra LED fixtures.[17]

Wastewater Treatment Biogas Purification/Flaring Reduction

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[14] Clean Technica. Scania Unveils Cutting Edge Battery- Electric Bus Platform at Busworld. Scania Unveils Cutting-Edge Battery-Electric Bus Platform at Busworld - CleanTechnica

[15] U.S. Environmental Protection Agency. Greenhouse Gases Equivalencies Calculator – Calculations and References. Greenhouse Gases Equivalencies Calculator - Calculations and References | US EPA

[16] P Fleet: Comparing Types of buses and their MPG. Comparing Types of Buses and Their MPG (pfleet.com)

[17] Ameresco Inc. Investment Grade Audit for PIDC at the Philadelphia Navy Yard. January 20, 2023. Available upon request.

Calculations were provided through two detailed professional energy assessments, which included analyses of energy-saving measures for implementation by the Philadelphia Water Authority.[18,19]

Community Composting Expansion Projects
GHG reductions from community composting program expansions were calculated using the EPA Waste Reduction Model (WARM).[20] Applicants provided completed models to PES for QC review. The final outputs from these WARM models were used directly to quantify CO_2e savings for these projects.

Table 4. Measure 1 Projects: GHG Emissions Reductions + Cost-Effectiveness Summary

MTCO2e Saved							CPRG Dollars Invested per MTCO2e Saved			
2025-2030		2025-2050					2025-2030		2025-2050	
Total Projects	Portion Funded by CPRG	Total Projects	Portion Funded by CPRG	**Aggregated Cost of Projects ($)^**	**CPRG Grant Amount ($)**	**% Funded**	CPRG Funding /MTCO2e Savings from CPRG Funding	CPRG Funding /MTCO2e Savings from Total Measure Cost	CPRG Funding /MTCO2e Savings from CPRG Funding	CPRG Funding /MTCO2e Savings from Total Measure Cost
60,787.4	46,168.2	574,068.5	452,943.1	$148,023,559	$91,419,303	62%	$1,980.13	$1,503.92	$201.83	$159.25

^Project budget as defined on pg. 1.

Measure 2: Actions to Implement Energy Efficiency, Electrification+Clean Energy for Residential Buildings
Actions to implement energy efficiency, electrification and clean energy for residential buildings include shovel-ready projects, with each project including one or more of the following scopes:

- Adaptive Reuse/Rehabilitation and Electrification of Commercial or Existing Residential Buildings for Residential Use, Largely Low-Income
- Addition of On-Site Solar PV Array Systems, some with Battery Storage, to offset Electrification and Achieve Net Zero Energy Consumption
- New Construction High-Efficiency Affordable Homes and Multifamily Apartment Units
- Heating Oil to Heat Pump Conversion Program.

For adaptive reuses/residential rehabilitations, new construction, and solar PV projects, methods described under Measure 1, beginning on pg. 4, were followed. The PES P.E. provided internal review of submitted energy modeling results from project owners and qualified mechanical engineering subcontractors. The PES P.E. also performed internal high-level modeling of reference case scenarios and project specifications for Measure 2 projects that required further assessment. For new construction, a "to-code" reference scenario was established and modeled using the data inputs and methods described earlier under Measure 1, beginning on pg. 4. These internal modeling outputs are available upon request.

Heating Oil to Heat Pump Conversion Program

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[18] Lehigh University Industrial Assessment Center Department of Mechanical Engineering and Mechanics. A Program Sponsored by the U.S. Department of Energy Advanced Manufacturing Office. Report LE0432. Available upon request.

[19] Mondre Energy, Inc. Philadelphia Water Department Biogas Delivery and Gas Flow Analyses: July 17, 2019, June 10, 2020, and May 27, 2022. Available upon request.

[20] U.S. Environmental Protection Agency. Waste Reduction Model (WARM). Waste Reduction Model (WARM) | US EPA. Models available upon request.

The project owner provided an Excel-based model quantifying the change in energy sources and consumption expected to result from the program's weatherization and fuel oil conversion projects. Weatherization savings were calculated based on U.S. Department of Energy data,[21] and heat pump conversion savings were determined from the appropriate sizing and type (single/multi-family) of homes contained in the National Renewable Energy Laboratory Residential Building End-Use Load Profiles.[22] The model was reviewed for accuracy by the PES P.E., and results were quantified using the CO_2e factors contained in this Technical Appendix, pgs. 1-4. The model is available on request.

Table 5. Measure 2 Projects: GHG Emissions Reductions + Cost-Effectiveness Summary

MTCO2e Saved				Aggregated Cost of Projects ($)^	CPRG Grant Amount ($)	% Funded	CPRG Dollars Invested per MTCO2e Saved			
2025-2030		2025-2050					2025-2030		2025-2050	
Total Projects	Portion Funded by CPRG	Total Projects	Portion Funded by CPRG				CPRG Funding /MTCO2e Savings from CPRG Funding	CPRG Funding /MTCO2e Savings from Total Measure Cost	CPRG Funding /MTCO2e Savings from CPRG Funding	CPRG Funding /MTCO2e Savings from Total Measure Cost
130,289.6	32,988.3	935,360.2	301,409.7	$270,203,915	$78,511,446	29%	$2,379.98	$602.59	$260.48	$83.94

^Project budget as defined on pg. 1.

Measure 3: Actions to Implement Energy Efficiency, Electrification+Clean Energy for Commercial Buildings
For Measure 3, the same methods and P.E. QC reviews as described under Measure 1, pgs. 4-7, were followed. Several programs are included in Measure 3 that required project-specific methodology:

- Philadelphia Green Capital CorporationCommercial Solar Incentive Program used methodology consistent with the solar PV array calculations outlined in this Technical Appendix p.2, based on the projected number of 250 kW solar PV arrays to be installed during the 5-year program.
- Philadelphia Energy Authority Small Business Energy Efficiency Program captured GHG savings using baseline energy use for reach-in and walk-in coolers and freezers from the Federal Energy Management Program.[23] A breakdown of cooler and freezer sizes among small businesses in the targeted region was estimated based on information provided by the PECO Small Business Solutions program staff. Fugitive refrigerant emissions savings resulting from maintenance and repairs were estimated based on EPA refrigerant charge data[24] as follows:

Calculation:

Lbs CO_2e leakage per unit per year

= Average refrigerant capacity per unit size (kg) * operational refrigerant emissions loss per year (expressed as % of capacity) * 1,300 GWP * 2.204623 kg/pound

Assumptions:

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[21] U.S. DOE Oak Ridge National Laboratory. Evaluation of the Weatherization Assistance Program During Program Years 2009-2011 (American Recovery and Reinvestment Act Period): Energy Impacts for Single Family Homes. ORNL_TM-2014_582.pdf

[22] Open Energy Data Initiative. ORNL_TM-2014_582.pdf

[23] U.S. Department of Energy Federal Energy Management Program. Purchasing Energy-Efficient Commercial Refrigerators and Freezers. Purchasing Energy-Efficient Commercial Refrigerators and Freezers | Department of Energy

[24] U.S. Environmental Protection Agency Center for Corporate Climate Leadership. Greenhouse Gas Inventory Guidance: Direct Fugitive Emissions from Refrigeration, Air Conditioning, Fire Suppression, and Industrial Gases. December 2023. Table 1. Page 11. Direct Fugitive Emissions from Refrigeration, Air Conditioning, Fire Suppression, and Industrial Gases (epa.gov)

For the first-year units undergo maintenance or repair, fugitive CO_2e emissions savings are estimated to be 100% of this calculated leakage. Operational fugitive emissions savings were reduced annually as a percentage of the calculated savings: Year 2 = 50%, Year 3 = 25%, Year 4 = 15%, Year 5 = 5%, Year 6 = 0%.

Table 6. Measure 3 Projects: GHG Emissions Reductions + Cost-Effectiveness Summary

MTCO2e Saved				Aggregated Cost of Projects ($)^	CPRG Grant Amount ($)	% Funded	CPRG Dollars Invested per MTCO2e Saved			
2025-2030		2025-2050					2025-2030		2025-2050	
Total Projects	Portion Funded by CPRG	Total Projects	Portion Funded by CPRG				CPRG Funding /MTCO2e Savings from CPRG Funding	CPRG Funding /MTCO2e Savings from Total Measure Cost	CPRG Funding /MTCO2e Savings from CPRG Funding	CPRG Funding /MTCO2e Savings from Total Measure Cost
137,910.7	129,102.8	181,717.2	164,083.5	$46,811,212	$17,491,911	37%	$135.49	$126.84	$106.60	$96.26

^Project budget as defined on pg. 1.

Measure 4: Actions to Transition Light-Duty Vehicles to Low- or No-Carbon Emission Vehicles

Measure 4 actions include public EV charger installations, including net-zero fast-charging stations along planned EV corridors in suburban areas that currently have little to no EV infrastructure. The following methodology was used to calculate public EV charger utilization and resultant CO_2e savings.

Calculations:

For grid-based EV charging (based on sample project with seven 2-port EV charging stations):

Total Lbs CO_2e Savings = Annual CO_2e from Equivalent Combustion Engine Miles - Annual CO_2e from EV Charging Stations

Annual Lbs CO_2e from EV Charging Stations

= (Estimated Annual Municipal Public EV Charging Station Usage in kWh per L2 Port * T&D Line Loss Multiplier * # of EV Ports * CO_2e per kWh)

= 3,663.2 kWh * **1.03369081038726** * 14 ports * **0.660236** CO_2e lbs/kWh

= 70,001 lbs CO_2e

Annual CO_2e from Equivalent Combustion Engine Miles

= ((Estimated Annual Municipal Public EV Charging Station Usage in kWh per L2 Port * T&D Line Loss Multiplier * # of EV Ports) / kWh per EV Mile[11]) * lbs CO_2e per mile from Gasoline Light-Duty Combustion Engine

= ((3,663.2 kWh * **1.03369081038726** * 14 ports) / 0.36) * 0.90460673

Whereas (as previously described under Metric 1, pg. 5):

Lbs CO_2e per mile from Gasoline Light-Duty Combustion Engine[12] = ((8,887 grams CO_2 per gallon of gasoline * 0.00220462 grams per pound) / 22.2 mpg average fuel economy) * 1.025 CO_2e factor

To determine annual CO_2e from EV charging station utilization, 2022 National Renewable Energy Laboratory municipal public EV charging station usage data were used to correlate kWh utilization per municipal charging port with the number of light-duty passenger EVs and hybrid EVs on the road in 2022.[25,26] Annual growth projections were then applied to kWh utilization per port based on projected

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[25] Pritchard E, Borlaug B, Yang F, et al. Evaluating Electric Vehicle Public Charging Utilization in the United States using the EV WATTS Dataset. National Renewable Energy Laboratory. June 2023. [Evaluating Electric Vehicle Public Charging Utilization in the United States using the EV WATTS Dataset: Preprint (nrel.gov)]

[26] National Renewable Energy Laboratory. The 2030 National Charging Network: Estimating U.S. Light-Duty Demand for Electric Vehicle Charging Infrastructure – A Nationwide Assessment. [The 2030 National Charging Network: Estimating U.S. Light-Duty Demand for Electric Vehicle Charging Infrastructure (nrel.gov)]

growth in the number of light-duty EVs and hybrid EVs to be on the road, with the aim of achieving the federal goal of 33 million EVs on the road by 2030.[22] This annual percentage increase in EVs on the road was applied to the kWh utilization per port year over year, and assessed with the understanding that ~25% of charging is performed using public chargers.[27]

On-site Solar PV+BESS-based Net-zero EV Charging

For net-zero EV charging projects, applicants provided annual charger utilization estimates (kWh) that increased year over year according to estimated adoption rates for a fast-charger corridor charger, as follows: Y2 60%, Y3 25%, Y4 25%, Y5 20%, Y6 4%, Y7 4%, Y8 4%, Y9 4%, Y10 4%. After Year 10, 100% of the solar PV kWhs are projected to be returned to the grid and were captured as such, since EV charging stations have a lifetime of ~10 years. Given that on-site battery storage systems are sized to eliminate any need for grid-based charging, the annual kWh charging utilization was subtracted from the total on-site solar PV array generation, and this excess generation was applied back to the grid.

Calculations:

GHG Savings from EV Charging = kWh Charged * Miles per kWh * Lbs CO_2e per mile from Gasoline Light-Duty Combustion Engine

Miles per kWh Charged = 1/kWh per mile[11]
= 1/0.36
= 2.78

Notes:

- Lbs CO_2e per mile from Gasoline Light-Duty Combustion Engine = 0.90460673
- See prior section, *grid-based EV charging*, for a description of the use of these factors, pg. 9.
- Savings were calculated as follows for KWh produced by the solar PV array and returned to the grid:
  Solar PV-Generated Grid-Returned kWh Savings
  = kWh remaining * T&D Loss Multiplier (**1.03369081038726**) * **0.660236** CO_2e lbs/kWh

Table 7. Measure 4 Projects: GHG Emissions Reductions + Cost-Effectiveness Summary

MTCO2e Saved				**Aggregated Cost of Projects ($)^**	**CPRG Grant Amount ($)**	**% Funded**	**CPRG Dollars Invested per MTCO2e Saved**			
2025-2030		**2025-2050**					**2025-2030**		**2025-2050**	
Total Projects	Portion Funded by CPRG	Total Projects	Portion Funded by CPRG				CPRG Funding /MTCO2e Savings from CPRG Funding	CPRG Funding /MTCO2e Savings from Total Measure Cost	CPRG Funding /MTCO2e Savings from CPRG Funding	CPRG Funding /MTCO2e Savings from Total Measure Cost
7,841.3	5,382.0	28,426.1	19,640.0	$6,675,599	$3,467,800	52%	$644.33	$442.25	$176.57	$121.99

^Project budget as defined on pg. 1.

[27] Frode P, Lee M, Sahdev S. McKinsey & Company. Can Public EV Fast-Charging Stations be Profitable in the United States? Can public EV fast-charging stations be profitable in the United States? | McKinsey