

California Air Resources Board

Quantification Methodology

**California Conservation Corps
Energy Corps**

California Climate Investments



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List of Acronyms and Abbreviations

| Acronym | Term |
|--------------------|--|
| CARB | California Air Resources Board |
| CCC | California Conservation Corps |
| CFL | compact fluorescent lamp |
| DC | direct current |
| g | grams |
| GGRF | Greenhouse Gas Reduction Fund |
| GHG | greenhouse gas |
| kW | kilowatts |
| kWh | kilowatt hours |
| lbs | pounds |
| LED | light-emitting diode |
| MTCO _{2e} | metric tons of carbon dioxide equivalent |
| NO _x | nitrous oxide |
| PM _{2.5} | particulate matter with a diameter less than 2.5 micrometers |
| PV | photovoltaic |
| ROG | reactive organic gas |
| W | watts |

Section A. Introduction

California Climate Investments is a statewide initiative that puts billions of Cap-and-Trade dollars to work facilitating GHG emission reductions; strengthening the economy; improving public health and the environment; and providing benefits to residents of disadvantaged communities, low-income communities, and low-income households, collectively referred to as “priority populations.” Where applicable and to the extent feasible, California Climate Investments must maximize economic, environmental, and public health co-benefits to the State.

CARB is responsible for providing guidance on estimating the GHG emission reductions and co-benefits from projects receiving monies from the GGRF. This guidance includes quantification methodologies, co-benefit assessment methodologies, and benefits calculator tools. CARB develops these methodologies and tools based on the project types eligible for funding by each administering agency, as reflected in the program expenditure records available at: <http://www.arb.ca.gov/cci-expenditurerecords>.

For the CCC Energy Corps, CARB staff developed this Energy Corps Quantification Methodology to provide guidance for estimating the GHG emission reductions and selected co-benefits from the implementation of energy efficiency retrofit projects.

The Energy Corps Benefits Calculator Tool automates methods described in this document, provides a link to a step-by-step user guide with a project example, and outlines documentation requirements. Projects will report the total project GHG emission reductions and co-benefits estimated using the Energy Corps Benefits Calculator Tool as well as the total project GHG emission reductions per dollar requested. The Energy Corps Benefits Calculator Tool is available for download at: www.arb.ca.gov/cci-resources.

Using many of the same inputs required to estimate GHG emission reductions, the Energy Corps Benefits Calculator Tool estimates the following co-benefits and key variables from Energy Corps projects:

- Statewide NO_x emission reductions (lbs);
- Statewide ROG emission reductions (lbs);
- Statewide PM_{2.5} emission reductions (lbs);
- Energy and fuel cost savings (dollars);
- Renewable energy generation (kWh); and
- Fossil fuel energy use reductions (kWh).

Additional co-benefits for which CARB assessment methodologies were not incorporated into the Energy Corps Benefits Calculator Tool may also be applicable to the project. Project sponsor should consult the Energy Corps Guidelines¹, solicitation materials, and agreements to ensure they are meeting Energy Corps requirements. All CARB co-benefit assessment methodologies are available at: www.arb.ca.gov/cci-cobenefits.

Methodology Development

CARB and CCC developed this Quantification Methodology consistent with the guiding principles of California Climate Investments, including ensuring transparency and accountability.² CARB and CCC developed this Energy Corps Quantification Methodology to be used to estimate the outcomes of proposed projects, inform project selection, and track results of funded projects. The implementing principles ensure that the methodology would:

- Apply at the project level;
- Provide uniform methods to be applied statewide and be accessible by all applicants;
- Use existing and proven tools and methods;
- Use project-level data, where available and appropriate; and
- Result in GHG emission reduction estimates that are conservative and supported by empirical literature.

CARB assessed peer-reviewed literature and tools and consulted with experts, as needed, to determine methods appropriate for Energy Corps energy efficiency retrofit and solar PV projects. CARB also consulted with CCC to determine project-level inputs available. The methods were developed to provide estimates that are as accurate as possible with data readily available at the project level.

The Energy Corps Benefits Calculator Tool was developed using data from the California Municipal Utilities Association's Savings Estimation Technical Reference Manual.³ The California Municipal Utilities Association compiles the Technical Reference Manual to document the data and methods that publicly owned utilities use to estimate energy savings from their programs. The Energy Corps Quantification Methodology is based on information and equations described in the Simplified Nonresidential Lighting Calculator. The Technical Reference Manual is available at: www.cmua.org/energy-efficiency-technical-reference-manual.

¹ California Conservation Corps. ccc.ca.gov/what-we-do/conservation-programs/energy-corps/

² California Air Resources Board. www.arb.ca.gov/cci-fundingguidelines

³ California Municipal Utilities Association. *Savings Estimation Technical Reference Manual* [Simplified Nonresidential Lighting Calculator]. 2017. www.cmua.org/energy-efficiency-technical-reference-manual

In addition, the University of California, Berkeley, in collaboration with CARB, developed assessment methodologies for a variety of co-benefits such as providing cost savings, lessening the impacts and effects of climate change, and strengthening community engagement. Co-benefit assessment methodologies are posted at: www.arb.ca.gov/cci-cobenefits.

CARB released the Draft Energy Corps Quantification Methodology and Draft Energy Corps Benefits Calculator Tool for public comment in September. This Final Energy Corps Quantification Methodology and accompanying Energy Corps Benefits Calculator Tool have been updated to address public comments, where appropriate, and for consistency with updates to the Energy Corps Guidelines.

Tools

For solar PV projects, the Energy Corps Benefits Calculator Tool relies on project-specific outputs from the National Renewable Energy Laboratory PVWatts® Calculator, a web-based tool that estimates the electricity production of grid-connected roof- or ground-mounted solar PV systems. PVWatts calculates estimated values for the proposed system's monthly and annual electricity production. For projects that include solar PV systems, the Energy Corps Benefits Calculator Tool relies on estimates of solar PV electricity generation from PVWatts. PVWatts is publicly available to anyone with internet access, free of charge, and subject to regular updates to incorporate new information. The tool can be accessed at: pvwatts.nrel.gov.

In addition to the Technical Reference Manual and PVWatts, the Energy Corps Benefits Calculator Tool relies on CARB-developed emission factors. CARB has established a single repository for emission factors used in CARB benefits calculator tools, referred to as the California Climate Investments Quantification Methodology Emission Factor Database, available at: www.arb.ca.gov/cci-resources. The Emission Factor Database Documentation explains how emission factors used in CARB benefits calculator tools are developed and updated.

Project sponsors must estimate the GHG emission reductions and co-benefits of the proposed project with the Energy Corps Benefits Calculator Tool. The Draft Benefits Calculator Tool and Draft Quantification Methodology are subject to change pending stakeholder comments and final Energy Corps Guidelines. The Energy Corps Benefits Calculator Tool can be downloaded from: www.arb.ca.gov/cci-resources.

Updates

CARB staff periodically review each quantification methodology to evaluate its effectiveness and update methodologies to make them more robust, user-friendly, and appropriate to the projects being quantified. CARB updated the Energy Corps Quantification Methodology and Energy Corps Benefits Calculator Tool from the previous versions⁴ to enhance the analysis and provide additional clarity, including the following additions:

- Equations to estimate GHG emission reductions and co-benefits from solar PV electricity generation; and
- Updated electricity price information.

⁴ California Air Resources Board. February 2019. <https://ww2.arb.ca.gov/our-work/programs/california-climate-investments/ci-archived-quantification-materials>

Section B. Methods

The following section provides details on the methods supporting emission reductions in the Energy Corps Benefits Calculator Tool.

Project Components

The CCC developed two types of projects that meet the objectives of the Energy Corps and facilitate the reduction of GHG emissions. Other project features may be eligible for funding under the Energy Corps; however, the Energy Corps Quantification Methodology provides methods to estimate GHG emission reductions from projects which install at least one of the following:

- Energy efficient lighting fixtures or controls; or
- Grid-connected solar PV system.

General Approach

This section describes the methods used in the Energy Corps Benefits Calculator Tool to estimate GHG emission reductions and air pollutant emission co-benefits. These methods account for reductions in electricity use from energy efficiency retrofits and the generation of solar PV electricity.

In general, GHG emission reductions are estimated in the Energy Corps Benefits Calculator Tool based on energy savings from reduced electricity use and avoided grid electricity production. The Energy Corps Benefits Calculator Tool also estimates air pollutant emission co-benefits and key variables using many of the same inputs used to estimate GHG emission reductions.

A. Emission Reductions from Energy Efficiency Retrofits

Emission reductions from energy efficiency retrofits are estimated from total energy savings using Equation 4. Equation 1 is used to estimate the annual energy use of each pre-existing and newly installed measure. Based on the difference between the project scenario and baseline scenario calculated in Equation 2, Equation 3 is used to determine total energy savings over the useful life of the project.

Equation 1: Measure-specific Energy Use

$$Energy\ Use = \frac{Watts}{1000} * Quantity * HVAC\ Interactive\ Effect * Lighting\ Operating\ Hours * (1 - Control\ Savings\ Factor)$$

| Where, | | Units |
|--------------------------|---|------------|
| Energy Use | = Annual energy consumption of pre-existing or installed measures | kWh/year |
| Watts | = Watts per pre-existing or installed lighting fixture | W |
| Quantity | = Number of pre-existing or installed lighting fixtures | unitless |
| HVAC Interactive Effect | = Building-specific effect factor for interaction between lighting, heating, and/or cooling energy in the climate zone where the project is located | unitless |
| Lighting Operating Hours | = Building-specific default annual lighting operating hours | hours/year |
| Control Savings Factor | = Control-specific default percent reduction in annual lighting operating hours | % |

Equation 2: Annual Energy Savings

$$Annual\ Energy\ Savings = Baseline\ Energy\ Use - Project\ Energy\ Use$$

| Where, | | Units |
|-----------------------|---|----------|
| Annual Energy Savings | = Annual reduction in energy use of all installed measures over all baseline measures | kWh/year |
| Baseline Energy Use | = Annual energy consumption of all pre-existing measures, summed from Equation 1 | kWh/year |
| Project Energy Use | = Annual energy consumption of all installed measures, summed from Equation 1 | kWh/year |

Equation 3: Lifetime Energy Savings

$$\text{Total Energy Savings} = \text{Annual Energy Savings} * \text{Useful Life}$$

| <i>Where,</i> | | <u>Units</u> |
|-----------------------|--|--------------|
| Total Energy Savings | = Total energy use reductions over the useful life of all installed measures | kWh |
| Annual Energy Savings | = Annual reduction in energy use of installed measures over pre-existing measures, from Equation 2 | kWh/year |
| Useful Life | = 15 years, default estimated useful life of installed measures ⁷ | years |

Equation 4: Emission Reductions from Energy Efficiency Retrofits

$$\text{Emission Reductions} = \text{Total Energy Savings} * \text{Emission Factor}$$

| <i>Where,</i> | | <u>Units</u> |
|----------------------|---|------------------------------------|
| Emission Reductions | = Total GHG or criteria and toxic air pollutant emission reductions for the useful life of all installed measures | MTCO ₂ e or lbs |
| Total Energy Savings | = Total energy use reductions over the useful life of all installed measures, from Equation 3 | kWh |
| Emission Factor | = Emission factor for California grid electricity | MTCO ₂ e/kWh or lbs/kWh |

B. Emission Reductions from Solar PV Systems

Emission reductions from grid-connected solar PV systems are estimated based on avoided fossil-fuel-based electricity generation, using Equation 5.⁵

Equation 5: Emission Reductions from Solar PV

$$Emission\ Reductions = \sum_{n=1}^{30} (1 - Degradation)^{n-1} * Production * EF$$

| Where, | | Units |
|----------------------------|---|------------------------------------|
| <i>Emission Reductions</i> | = Total GHG or criteria and toxic air pollutant emission reductions for the useful life of the solar PV system (30 years) | MTCO _{2e} or lbs |
| <i>Degradation</i> | = Annual rate of system degradation (0.5%) | %/year |
| <i>Production</i> | = Annual electricity generation estimated using PVWatts Calculator | kWh/year |
| <i>EF</i> | = Emission factor for California grid electricity | MTCO _{2e} /kWh or lbs/kWh |

⁵ The 30-year useful life was obtained from the National Renewable Energy Laboratory "Life Cycle Greenhouse Gas Emissions from Solar Photovoltaics" fact sheet.

www.nrel.gov/docs/fy13osti/56487.pdf

The estimated rate of system degradation was obtained from the National Renewable Energy Laboratory Technical Report "Photovoltaic Degradation Rates – An Analytical Review." 2012.

www.nrel.gov/docs/fy12osti/51664.pdf

Section C. References

The following references were used in the development of this Quantification Methodology and the Energy Corps Benefits Calculator Tool.

California Air Resources Board (2019). *California Climate Investments Quantification Methodology Emission Factor Database*. www.arb.ca.gov/cci-resources

California Municipal Utilities Association (2017). *Savings Estimation Technical Reference Manual* [Simplified Nonresidential Lighting Calculator]. www.cmua.org/energy-efficiency-technical-reference-manual

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