

California Air Resources Board

Quantification Methodology

Department of Community Services and Development

**Low-Income Weatherization Program:
Single-Family Energy Efficiency and Solar Photovoltaics
Multi-Family Energy Efficiency and Renewables**

California Climate Investments



February 28, 2023

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Section A. Introduction

California Climate Investments is a statewide initiative that puts billions of Cap-and-Trade dollars to work facilitating greenhouse gas (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.

The California Air Resources Board (CARB) is responsible for providing guidance on estimating the GHG emission reductions and co-benefits from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF). This guidance includes quantification methodologies, co-benefit assessment methodologies, and benefits calculator tools. CARB develops these methodologies and tools based on the project activities eligible for funding by each administering agency, as reflected in the program expenditure records available at: www.arb.ca.gov/cci-expenditurerecords.

For the Department of Community Services and Development’s (CSD) Low-Income Weatherization Program (LIWP), CARB staff developed this LIWP Quantification Methodology to provide guidance for estimating the GHG emission reductions and selected co-benefits of each proposed project activity. This methodology uses calculations to estimate GHG emission reductions from displacing fossil fuel-generated electricity with rooftop solar electricity, and reducing energy use due to energy efficiency measures installed by LIWP projects.

The LIWP Benefits Calculator Tool automates methods described in this document, provides a link to a step-by-step user guide, and outlines documentation requirements. CSD and service providers will use this quantification methodology as demonstrated in the LIWP Benefits Calculator Tool to estimate the total project GHG emission reductions and co-benefits as well as the total project GHG emission reductions per dollar of GGRF requested and implemented for reporting purposes. The LIWP Benefits Calculator Tool is available for download at: <http://www.arb.ca.gov/cci-resources>.

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

- Select criteria and toxic air pollutant reductions over the quantification period (in pounds (lbs)), including nitrogen oxide (NO_x), reactive organic gases (ROG), and fine particulate matter less than 2.5 micrometers (PM_{2.5});
- Total energy savings over the quantification period (in kWh and therms);
- Total energy cost savings over the quantification period (in \$);
- Total renewable electricity generation over the quantification period (in kWh); and
- Total water savings over the quantification period (in gallons).

Key variables are project characteristics that contribute to a project's GHG emission reductions and signal an additional benefit (e.g., renewable energy generated). CSD and service providers will also use the Climate Adaptation Co-benefit Assessment Methodology, which was not incorporated into the LIWP Benefits Calculator Tool. All CARB co-benefit assessment methodologies are available at: www.arb.ca.gov/ccicobenefits.

Methodology Development

CARB and CSD developed this Quantification Methodology consistent with the guiding principles of California Climate Investments, including ensuring transparency and accountability.¹ CARB and CSD developed this LIWP 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 CSD and all service providers;
- 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 the LIWP project activities. CARB also consulted with CSD to determine project-level inputs available. The methods were

¹ CARB (2018). Funding Guidelines for Agencies that Administer California Climate Investments. Available at: www.arb.ca.gov/cci-fundingguidelines

developed to provide estimates that are as accurate as possible with data readily available at the project level.

CARB released the Draft LIWP Quantification Methodology and Draft LIWP Benefits Calculator Tool for public comment in February 2023. This Final LIWP Quantification Methodology and accompanying LIWP Benefits Calculator Tool have been updated to address received comments, where appropriate.

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. As they become available, co-benefit assessment methodologies are posted at: www.arb.ca.gov/cci-cobenefits.

Tools

The LIWP Benefits Calculator Tool relies on energy savings estimates from energy saving measures, appliance upgrades, and solar photovoltaic (PV) installations. CSD estimates project-specific energy savings based on the individual measures installed in a home using a number of publicly available data sources. The tables in Section C list the data sources used for individual measures that are not calculated using audit software (see Section B for more information). CSD's service providers use the following tools for conducting home energy audits and solar PV estimates:

Service providers currently use Snugg Pro and EnergyPro to create a "whole building" analysis of the energy performance of dwellings, identify opportunities for energy efficiency improvements, and to estimate energy savings for various energy efficiency measures available under LIWP. These software packages determine the dwelling energy load and estimate energy consumption from existing dwelling characteristics such as the dwellings size, thermal boundary, location, number of occupants, and equipment. They generate a whole-building estimate of energy savings from all selected efficiency measures. This energy audit software has been approved by the California Energy Commission and by Energy Upgrade California for use in other incentive programs to estimate energy savings for various energy efficiency measures available under LIWP. These tools are used statewide, are subject to regular updates to incorporate new information, are based on publicly available information. They can be accessed at: <https://snuggpro.com/> and <http://www.energysoft.com/>.

The National Renewable Energy Laboratory (NREL) PVWatts® Calculator is a web-based tool that estimates the electricity production of a grid-connected roof- or ground-mounted solar PV system based on simple inputs. PVWatts calculates estimated values for the proposed system's monthly and annual electricity production.

The tool is used statewide, publicly available, subject to regular updates to incorporate new information, free of charge, and available to anyone with internet access. The tool can be accessed at: <http://pvwatts.nrel.gov/>.

In addition to the tools above and data sources listed in Section C, the LIWP 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: <http://www.arb.ca.gov/cci-resources>.

The Database Documentation explains how emission factors used in CARB benefits calculator tools are developed and updated.

CSD and their service providers will use this quantification methodology to estimate the GHG emission reductions and co-benefits of proposed and implemented projects, as demonstrated by the calculations included in the LIWP Benefits Calculator Tool. The LIWP Benefits Calculator Tool can be downloaded from: <http://www.arb.ca.gov/cci-resources>.

Updates

CARB staff periodically review each Quantification Methodology and benefits calculator tool to evaluate their effectiveness and update methodologies to make them more robust, user-friendly, and appropriate to the projects being quantified. CARB updated the LIWP Quantification Methodology from the previous version² to enhance the analysis and provide additional clarity.

The changes include:

- Updated deemed savings and effective useful life values for efficiency measures with well-known and consistent performance not dependent on individual dwelling characteristics;
- Quantification of emission reductions associated with early replacement of heating and air conditioning equipment with equipment using refrigerants with a lower global warming potential (GWP);

² CARB (2019). Quantification Methodology for the Department of Community Services and Development Low-Income Weatherization Program: Single-Family Energy Efficiency and Solar Photovoltaics; Multi-Family Energy Efficiency and Renewables. Available at: https://ww2.arb.ca.gov/sites/default/files/auction-proceeds/csd_liwp_finalqm_012219.pdf

- An updated LIWP Benefits Calculator Tool that uses this quantification methodology to estimate energy savings, energy generation, GHG reductions, and co-benefits of LIWP projects; and
- An updated User Guide, including an example project scenario.

Section B. Methods

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

Project Activities

CSD developed four project activities that meet the objectives of LIWP and for which there are methods to quantify GHG emission reductions.³ Other project features may be eligible for funding under LIWP; however, each project requesting GGRF funding must include at least one of the following:

- Energy Efficiency Measures
- Solar PV
- Solar Water Heaters
- Heating and Air Conditioning Systems

General Approach

Methods used in the LIWP Benefits Calculator Tool for estimating the GHG emission reductions and air pollutant emission co-benefits by activity type are provided in this section. The Database Documentation explains how emission factors used in CARB benefits calculator tools are developed and updated.

These methods account for fossil fuel energy that is displaced or reduced by energy efficiency measures and solar PV energy generation. In general, the GHG emission reductions are estimated in the LIWP Benefits Calculator Tool using the approaches in Table 1. The LIWP 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.

³ CSD program guidelines are found at: <https://www.csd.ca.gov/Pages/Low-Income-Weatherization-Program.aspx>

Table 1. General Approach to Quantification by Project Activity

Energy Efficiency
<i>Emission reductions = Estimated energy savings from measures installed * emission factor</i>
Solar PV
<i>Emission reductions = Estimated solar energy generation * emission factor</i>
Refrigerant Replacement and Leakage Reduction
<i>Emission reductions = Estimated refrigerant emissions during remaining useful life of baseline equipment – Estimated refrigerant emissions over remaining useful life of baseline equipment</i>

I. Emission Reductions from Energy Efficiency Measures

Both the GHG emission reductions and air pollutant emission reductions from energy efficiency measures are estimated as the difference between the baseline and project scenarios using Equation 1.

Equation 1. Emission Reductions from Energy Efficiency Measures

$Emission\ Reductions = \left(\sum S_{electricity} \times EUL \right) \times EF_{electricity} + \left(\sum S_{NG} \times EUL \right) \times EF_{NG}$		
<i>Where,</i>		<u>Units</u>
$S_{electricity}$	= Estimated annual energy savings for each measure	kWh per year
EUL	= Effective useful life for each energy efficiency measure installed, or their weighted average	years
$EF_{electricity}$	= Emission factor for electricity	MTCO ₂ e per kWh; or lbs per kWh
S_{NG}	= Estimated annual fuel savings for each measure	therms per year
EF_{NG}	= Emission factor for fuel	MTCO ₂ e per therm; or lbs per therm

II. Solar Water Heater Installation

GHG emission reductions from solar water heater installation are estimated as the difference between the baseline and project scenarios using Equation 2.

Equation 2. Emission Reductions from Solar Water Heater Installation

$Emission\ Reductions = \left[\sum_{n=1}^{25} [1 - (n)(R_{degradation})] (GHG_{per\ system}) \right] \times SWH_{total}$		
Where,		<u>Units</u>
n	= Any given year	
25	= Estimated useful life of solar thermal systems ⁴	years
$R_{degradation}$	= Rate of system degradation (0.5)	% per year
$GHG_{per\ system}$	= GHG emission reduction per system derived from CSI Thermal Calculator	MTCO _{2e}
SWH_{total}	= Number of SWH systems to be installed	

III. Emission Reductions from Solar PV Installation

Both the GHG emission reductions and air pollutant emission reductions from solar PV installation are estimated as the difference between the baseline and project scenarios using Equation 3.

Equation 3. Emission Reductions from Solar PV Installation

$Emission\ Reductions = \sum_{n=1}^{30} (1 - R_{degradation})^{n-1} (PV_{production}) (EF_{electricity})$		
<i>Where,</i>		<u>Units</u>
<i>n</i>	= Any given year	
30	= Estimated useful life of solar PV systems ⁵	years
<i>R_{degradation}</i>	= Rate of system degradation (0.5)	% per year
<i>PV_{production}</i>	= Annual electricity generated based on PVWatts Calculator	kWh per year
<i>EF_{electricity}</i>	= Emission factor for electricity	MTCO ₂ e per kWh; or lbs per kWh

IV. Emission Reductions from Stationary Heating and Air Conditioning Systems Refrigerant Replacement and Leakage Reduction

The GHG emission reductions from heating and air conditioning (AC) systems refrigerant replacement and leakage reduction is estimated by summing the total annual GHG emission reductions over the remaining useful life of the baseline equipment and the end-of-life GHG emission reductions, according to Equation 4.

Equation 4. Emission Reductions from Refrigerant Replacement and Leakage Reduction

<i>Emission Reductions</i>		
$= Emission\ Reductions_{Total\ Annual} + Emission\ Reductions_{End-of-Life}$		
<i>Where,</i>		<u>Units</u>
<i>Emission Reductions</i>	= Total GHG emission reductions from refrigerant replacement and leakage reduction (sum of all refrigerants). ⁶	MTCO ₂ e
<i>Emission Reductions Total Annual</i>	= Total annual GHG emission reductions from refrigerant replacement and leakage reduction (sum of all refrigerants).	MTCO ₂ e
<i>Emission Reductions End-of-Life</i>	= End-of-life GHG emission reductions from refrigerant replacement and leakage reduction (sum of all refrigerants).	MTCO ₂ e

Technicians performing maintenance or installation of air conditioning (AC) or heat pump equipment must possess EPA Section 608 certification and a California C-20 contractor’s license. When performing maintenance and repair, technicians must locate and repair leaks in AC equipment being serviced. Section 608 of the Clean Air Act prohibits venting ozone-depleting refrigerants (including HCFC-22) as well as their substitutes (such as HFCs, including R-410A), while maintaining, servicing, repairing, or disposing of AC and refrigeration equipment. Disposal of old AC units and refrigerant reclamation must comply with all applicable laws.

Technicians can return recovered refrigerant to a consolidator (such as a refrigerant manufacturer, supplier, wholesale distributor, or refrigerant recovery company) for packaging and preparation prior to reclamation, or in some cases directly to an [EPA-certified refrigerant reclaiming](#). These entities offer payment for recovered refrigerants. Equipment can be disposed of at specific facilities that are part of the RAD program or

may be turned in at metal/scrap recycling facilities for some payment. [EPA's RAD program](#) can help easily locate facilities that collect used refrigerated appliances and implement best practices for the recycling/disposal. In some cases, financial incentives may be offered for turning in old units. These financial incentives are unable to be quantified as co-benefits of the project at this time.

The remaining useful life of the baseline system replaced by the project equipment is used to estimate the associated GHG emissions avoided from system replacement. In Equation 5, the remaining useful life of the baseline equipment is calculated by determining the age of the baseline equipment from the difference of the installation year and the manufacture year, and then subtracting the age of the equipment from the effective useful life of the baseline equipment.

Equation 5. Remaining Useful Life of Baseline Stationary Heating and Air Conditioning Systems

$RUL_{Baseline} = EUL_{Baseline} - (Install\ Yr_{Project} - Manufacture\ Yr_{Baseline})$		
Where,		<u>Units</u>
$RUL_{Baseline}$	= Remaining useful life of the baseline equipment, calculated as of the date of installation of the project equipment.	yr
$EUL_{Baseline}$	= Effective useful life of the baseline equipment, according to survey data used to support the CARB High GWP Gases GHG emissions inventory ⁶ as shown in Table 2.	yr
$Install\ Yr_{Project}$	= Year project equipment is installed.	yr
$Manu-facture\ Yr_{Baseline}$	= Year baseline equipment was manufactured	yr

By January 1, 2025, manufacturers of residential heating and air conditioning equipment must comply with regulations that will require use of a low GWP refrigerant (GWP<750). Emission reductions are estimated only for early replacement of equipment and only for equipment replacements exceeding compliance with

regulatory requirements at the time of installation.⁴

GHG emission reductions are estimated as the difference between the baseline and project scenarios. To estimate the total annual GHG emission reductions from refrigerant replacement and leakage reduction, the sum of the GHG emissions from all refrigerants in the project heating and air conditioning systems are subtracted from the sum of the GHG emissions from all refrigerants in the baseline heating and air conditioning systems, according to Equation 6.

The end-of-life GHG emission reductions are similarly estimated from the difference of the GHG emissions from the project and baseline heating and air conditioning systems, using Equation 7. These are the GHG emissions avoided at the end of the life of heating and air conditioning equipment.

Table 2 contains default values for stationary heating and air conditioning systems that may be used if actual values are not available.

⁴ Please note that refrigerant emission reductions are estimated to be zero for:

- Projects where the remaining useful life of the baseline equipment is less than one year, and
- Projects that are installing equipment that meet minimum regulatory requirements at the time of installation.

CARB (2020). Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Chillers, Aerosols-Propellants, and Foam End-Uses Regulation. Available at: <https://ww2.arb.ca.gov/rulemaking/2020/hfc2020>

Equation 6. Total Annual GHG Emission Reductions from AC System Refrigerant Replacement and Leakage Reduction

$$\begin{aligned}
 & \text{Emission Reductions}_{Total\ Annual} \\
 &= \sum_{i=1}^n \left(RC_{baseline} \times GWP_{baseline} \times LP_{baseline} \times \frac{N_i}{2,204.6} \times RUL_{baseline} \right) \\
 & - \sum_{j=1}^m \left(RC_{project} \times GWP_{project} \times LP_{project} \times \frac{N_j}{2,204.6} \times RUL_{baseline} \right)
 \end{aligned}$$

Where,

Emission Reductions_{Total Annual}	= Total annual GHG emission reductions from refrigerant replacement and leakage reduction (sum of all refrigerants).	<u>Units</u> MTCO ₂ e
RC_{baseline}	= Refrigerant charge of the baseline equipment. If unknown, default values from Table 2 may also be used.	lb
GWP_{baseline}	= Global Warming Potential of the baseline refrigerant. ⁸	MTCO ₂ e/MT
LP_{baseline}	= Refrigerant leakage rate of the baseline equipment. If unknown, default values from Table 2 may also be used.	%/yr
RC_{project}	= Refrigerant charge of the equipment proposed by the project.	lb
GWP_{project}	= Global Warming Potential of the refrigerant proposed by the project. ⁶	MTCO ₂ e/MT
LP_{project}	= Refrigerant leakage rate of the equipment proposed by the project. If unknown, default values from Table 2 may also be used.	%/yr
N_x	= Number of identical units.	Units
2,204.6	= Conversion factor from pounds to metric tons.	lb/MT
RUL_{baseline}	= Remaining Useful Life of the baseline unit, ⁶ calculated according to Equation 5.	yr
n or m	= Number of baseline or project refrigerants.	Unitless

Equation 7. End-of-Life Emission Reductions from Heating and Air Conditioning System Refrigerant Replacement and Leakage Reduction

*Emission Reductions*_{End-of-Life}

$$= \sum_{i=1}^n \left(RC_{EOLbaseline} \times GWP_{baseline} \times LP_{EOLbaseline} \times \frac{N_i}{2,204.6} \right) - \sum_{j=1}^m \left(RC_{EOLproject} \times GWP_{project} \times LP_{EOLproject} \times \frac{N_j}{2,204.6} \right)$$

<i>Where,</i>		<u>Units</u>
<i>Emission Reductions</i> _{End-of-Life}	= End-of-life GHG emission reductions from refrigerant replacement and leakage reduction (sum of all refrigerants).	MTCO ₂ e
<i>RC</i> _{EOLbaseline}	= Refrigerant charge at end-of-life for the baseline equipment, according to Table 2 default values.	lb
<i>GWP</i> _{baseline}	= Global Warming Potential of the baseline refrigerant. ⁶	MTCO ₂ e/MT
<i>LP</i> _{EOLbaseline}	= Average end-of-life refrigerant leakage rate of the baseline equipment, according to Table 2 default values.	%
<i>RC</i> _{EOLproject}	= Average refrigerant charge at end-of-life for the equipment proposed by the project, according to Table 2 default values.	lb
<i>GWP</i> _{project}	= Global Warming Potential of the refrigerant proposed by the project. ⁶	MTCO ₂ e/MT
<i>LP</i> _{EOLproject}	= Average end-of-life refrigerant leakage rate of the equipment proposed by the project, according to Table 2 default values.	%
<i>N</i> _x	= Number of identical units.	Units
2,204.6	= Conversion factor from pounds to metric tons.	lb/MT

Table 2. Default Values for Stationary Heating and Air Conditioning Systems^{Error!}Bookmark not defined.,⁵

System Type	Lifetime (yr)	Average Refrigerant Charge (lb)	Average End-of-Life Refrigerant Charge (lb)	Average Annual Leak Rate (%/yr)	Average End-of-Life Leak Rate (%)
Room AC (window/wall)	12	1.54	1.17	2.0	98.5
Room AC (PTAC/PTHP)	12	1	NA ⁶	2	98.5
Residential AC	15	8.157	5.3	5.3	80.0
Residential HP	15	8.2	NA ⁶	5	80
Commercial AC (≥ 65k to <135,000k Btu/hr)	20	25	12.1	10.0	56.0
Commercial AC (≥ 135,000k Btu/hr)	20	60	89	7.0	20.0

⁵ California Air Resources Board. (2020). Amendments to the Prohibitions on Use of Certain Hydrofluorocarbons in Stationary Refrigeration, Chillers, Aerosols, Propellants, and Foam End-Uses Regulation, available at:

<https://ww2.arb.ca.gov/sites/default/files/barcu/regact/2020/hfc2020/appb.pdf>

⁶ Due to lack of survey data, for Room AC (PTAC/PTHP) and Residential HP the Average End-of-Life Refrigerant Charge is assumed to be equal to the Average Refrigerant Charge.

Estimates for Proposed Projects

Energy efficiency project GHG emission reduction estimates are used for comparing proposals from potential LIWP service providers and are based on the projected number of dwellings served and the average annual energy savings achieved per dwelling. The average per dwelling energy savings value is an estimate developed by CSD based on historical average energy savings of over 6,000 households served by projects implemented between 2019 and 2022. It includes average savings for a variety of measures installed in a sample dwelling across varying climate zones and heating fuels used in a dwelling. CSD will use the LIWP Benefits Calculator Tool with the statewide historical averages in Table 3 to evaluate proposed projects.

Table 3. Average Annual Reductions from Energy Efficiency Measures

Dwelling Type	Annual Reduction in kWh	Annual Reduction in therms
Single-Family	2,430 per dwelling	74.0 per dwelling
Multi-Family	1,947 per dwelling	98.1 per dwelling

Estimates for Implemented Projects

LIWP service providers conduct a home energy assessment to generate a list of recommended measures that can improve the energy efficiency of the dwelling. LIWP service providers use audit software like Snugg Pro or EnergyPro to determine the estimated savings from measures whose performance is dependent on the conditions of the individual home. For measures with well-known and consistent performance not dependent on individual dwelling characteristics, deemed energy savings are calculated by multiplying the number of installed measures by a deemed energy savings value per measure, using the data sources listed in Section C. Deemed energy saving measures in the California Electronic Technical Reference Manual (eTRM) may be updated as standards become available for measures and old standards expire.

CSD will compile information from LIWP service providers on implemented projects and use this quantification methodology to estimate GHG reductions for reporting. Project energy savings will vary by dwelling due to variations in dwelling type, location, and the number and types of measures installed. LIWP service providers will estimate energy savings and energy generation based on the individual characteristics of a dwelling using audit software like Snugg Pro or EnergyPro, deemed energy savings estimates, industry standard databases and peer-reviewed workpapers cited in Section C, and PVWatts. For all installed measures funded by GGRF, LIWP service providers submit periodic reports that document dwelling specific characteristics such as location data, heating fuel type, and details on each installed measure. CSD uses this data to identify climate-zone-specific energy savings for each dwelling.

Section C. References – Measure Energy Savings

CSD uses a variety of sources to estimate the energy savings of all available measures. The databases and sources listed below contain deemed savings and effective useful life values for a variety of measures. Deemed savings values are evaluations of the historical energy savings achieved by simpler efficiency measures with well-known and consistent performance not dependent on individual dwelling characteristics.

Table 4 lists the references used for deemed energy savings values. Table 5 lists the installation measures that may require audit software to estimate the energy savings. Table 6 lists the specific data sources for individual deemed energy savings values for single-family and multi-family dwellings, and Table 7 lists the specific data sources for deemed energy savings values for measure installations that are restricted to installation in multi-family dwellings. Table 8 and Table 9 list the data sources that are used for the energy audit software SnuggPro and EnergyPro, respectively.

Table 4. Reference Sources for Energy Savings

Reference Source	Website
California Electronic Technical Reference Manual (eTRM)	https://www.caetrm.com/
Savings Estimation Technical Reference Manual 2017 for the California Municipal Utilities Association (CMUA)	https://www.cmua.org/energy-efficiency-technical-reference-manual
Database for Energy Efficient Resources (DEER)	http://www.deeresources.com/ http://deeresources.net/workpapers
Non-DEER measure work papers and CPUC dispositions	http://www.deeresources.com/index.php/non-deer-workpapers https://cedars.sound-data.com/deer-resources/
Energy Savings Assistance (ESA) Program	http://www.calmac.org/ http://eestats.cpuc.ca.gov/
ENERGY STAR®	https://www.energystar.gov/
NREL PVWatts® Calculator	http://pvwatts.nrel.gov/

Table 5. Measures Estimated Using Audit Software

Ceiling/Roof/Attic Insulation*	Chiller Plant / Cooling Tower**
Clothes Dryer Replacement	Cold Water Booster Pump**
Cool Roof	Duct Insulation*
Duct Replacement or Sealing	Electric Oven / Electric Range*
Exhaust Fans**	Floor Insulation
Heat Pump Water Heater*	Heating and Cooling Source Replacements*
Pipe Insulation**	Pool Pump**
Radiant Barrier	Thermostatic Radiator Valve**
Crawlspace Insulation	Water Heater Replacement* (or Boiler Replacement**)*
Window Film	Window Replacement

* Specific measures may alternatively be quantified using deemed energy savings estimates, where applicable.

** Measures Restricted to Multi-family Properties

Table 6. Data Sources for Individual Deemed Measures in Single-family and Multi-family Dwellings

LIWP Measure	Energy Savings Reference
Ceiling Fans	Savings Estimation Technical Reference Manual 2017 for the California Municipal Utilities Association; TRM206 Available at: https://www.cmua.org/energy-efficiency-technical-reference-manual
Ceiling/Attic Insulation	eTRM Statewide Measure ID SWBE006-01. Ceiling Insulation, Residential. EUL ID: BS-Ceillns. DEER Database READI v.2.5.1 Measure IDs RB-BS-Ceillns-R0-R30, RB-BS-Ceillns-R0-R38, RB-BS-Ceillns-VintR-AddR11, RB-BS-Ceillns-VintR-AddR19, RB-BS-Ceillns-VintR-AddR30. Available at: https://www.caetrm.com/measure/SWBE006/01/ OR Energy savings quantified using energy audit.
Clothes Dryer Replacement	eTRM Statewide Measure ID SWAP003-04. Clothes Dryer, Residential. Statewide Measure Offering ID: B. EUL ID: Appl-EffCD. Available at: https://www.caetrm.com/measure/SWAP003/04/ OR eTRM Statewide Measure ID SWAP014-02. Heat Pump Clothes Dryer, Residential Fuel Substitution. Available at: https://www.caetrm.com/measure/SWAP014/02 OR Energy audit tool or ENERGY STAR Product Finder: https://www.energystar.gov/productfinder/product/certified-clothes-dryers
Clothes Washer Replacement (in unit)	California Air Resources Board Greenhouse Gas Emission Reduction Calculator for the Department of Water Resources Water-Energy Grant Program Greenhouse Gas Reduction Fund Fiscal Year 2015-16. Version 3 – October 6, 2017. ⁷ OR

⁷ This resource has been archived from the www.arb.ca.gov/cci-resources website. Please contact GGRFprogram@arb.ca.gov for access.

LIWP Measure	Energy Savings Reference
	eTRM Statewide Measure ID SWAP004-02 Available at: www.caetrm.com/measure/SWAP004/02/ OR Energy savings quantified using energy audit tool
Clothes Washer Replacement (central)	eTRM Statewide Measure ID SWAP004-03 Available at: https://www.caetrm.com/measure/SWAP004/03/ OR Energy savings quantified using energy audit tool
Dishwasher Replacement	eTRM Statewide Measure ID SWAP006-04. Dishwasher, Residential. EUL ID: Appl-EffDW. Available at: https://www.caetrm.com/measure/SWAP006/04/
Efficient Fan Controller, "Enhanced Time Delay"	eTRM Statewide Measure ID SWHC029-02. Fan Controller for Air Conditioner, Residential. EUL ID: HV-ResAC Available at: https://www.caetrm.com/measure/SWHC029/02/
ECM Blower Motor	eTRM Statewide Measure ID SWHC038-03. Brushless Fan Motor Replacement, Residential. EUL ID: HV-BFMotor Available at: https://www.caetrm.com/measure/SWHC038/03/ AND Workpaper disposition for Residential HVAC Quality Maintenance CPUC May 2, 2013. Available at: https://cedars.sound-data.com/deer-resources/deemed-measure-packages/dispositions/
Efficient Fan Controller, "Enhanced Time Delay"	eTRM Statewide Measure ID SWHC029-02. Fan Controller for Air Conditioner, Residential. EUL ID: HV-ResAC Available at: https://www.caetrm.com/measure/SWHC029/02/
Exterior Security Light (w/ Photocell and Motion Sensor)	DEER Database READI v.2.5.1 (Current Ex Ante data) options: include Non-DEER data; 1/1/2013 - 1/1/2021. Measure ID R-OutDD-CFLfixt-20w-ext(20w)-dWP50. Available at: http://www.deeresources.com/
Faucet Restrictor	California Air Resources Board Greenhouse Gas Emission Reduction Calculator for the Department of Water Resources

LIWP Measure	Energy Savings Reference
	<p>Water-Energy Grant Program Greenhouse Gas Reduction Fund Fiscal Year 2015-16. Version 3 – October 6, 2017.⁷</p> <p>OR</p> <p>eTRM Statewide Measure ID SWWH001-03 Available at: https://www.caetrm.com/measure/SWWH001/03/</p> <p>OR</p> <p>Energy savings quantified by energy audit tool</p>
Floor Insulation	<p>DEER Database READI v.2.5.1 (Current Ex Ante data) options: include Non-DEER data; 1/1/2013 - 1/1/2021. Measure ID D03-426.</p> <p>Available at: http://www.deeresources.com/</p> <p>OR</p> <p>Energy savings quantified using energy audit.</p>
Freezer Replacement	<p>eTRM Statewide Measure ID SWAP001-04. Refrigerator or Freezer, Residential. EUL ID: Appl-ESFrzr.</p> <p>Available at: https://www.caetrm.com/measure/SWAP001/04/</p>
Infiltration Reduction	<p>PY2011 Energy Savings Assistance Program Impact Evaluation Final Report, Study ID: SDG0273.01 August 30, 2013.</p> <p>Available at: https://www.calmac.org/publications/2011_ESA_Impact_Evaluation_FINAL.pdf</p> <p>OR</p> <p>Energy savings quantified using energy audit.</p>
LED Bulbs	<p>Savings Estimation Technical Reference Manual 2017 for the California Municipal Utilities Association; TRM204_residential-LED_v3 15 2016.</p> <p>Available at: https://www.cmua.org/energy-efficiency-technical-reference-manual</p> <p>OR</p> <p>Energy savings quantified using energy audit.</p>
LED Night Lights	<p>SCE work paper, SCE13LG029 LED, Electroluminescent plug-in night lights, August 25, 2012. Measure Name: 0.3 Watt Night Light LED replacing Incandescent Night Light.</p> <p>Available at: http://deeresources.net/workpapers</p>

LIWP Measure	Energy Savings Reference
Lighting (other)	ETRM Statewide Measure IDs: SWLG018-03, SWLG012-01, SWLG009-04 Available at: https://www.caetrm.com/measure/SWLG018/03/ https://www.caetrm.com/measure/SWLG012/01/ https://www.caetrm.com/measure/SWLG009/04/ OR Energy savings quantified by energy audit.
Low Flow Showerhead/ Hand-Held Low Flow Showerhead	California Air Resources Board Greenhouse Gas Emission Reduction Calculator for the Department of Water Resources Water-Energy Grant Program Greenhouse Gas Reduction Fund Fiscal Year 2015-16. Version 3 – October 6, 2017. ⁷
Oven/Range (fuel switch)	eTRM Statewide Measure ID SWAP013-02 Cooking Appliances, Residential, Fuel Substitution Available at: https://www.caetrm.com/measure/SWAP013/02/
Pipe Insulation (for in-unit DHW)	ETRM Statewide Measure ID SWWH026-02 Available at: https://www.caetrm.com/measure/SWWH026/02/
Refrigerant Charge and Coil Cleaning	eTRM Statewide Measure ID SWSV006-01. Refrigerant Charge Adjustment, Residential. SWSV007-01. Condenser Coil Cleaning, Residential. SWSV008-01. Evaporator Coil Cleaning, Residential. EUL ID: HV-RefChrg and HV-ResAC-CleanCoil. Available at: https://www.caetrm.com/measure/SWSV006/01/ https://www.caetrm.com/measure/SWSV007/01/ https://www.caetrm.com/measure/SWSV008/01/
Refrigerator Replacement	ETRM Statewide Measure ID SWAP001-04 Available at: https://www.caetrm.com/measure/SWAP001/04/ OR ENERGY STAR Flip Your Fridge Calculator. Available at: https://www.energystar.gov/products/appliances/refrigerators/flip-your-fridge
Smart Thermostat	eTRM Statewide Measure ID SWHC039-05. Smart Thermostat, Residential. EUL ID: HV-SmartTstat. Available at: https://www.caetrm.com/measure/SWHC039/05/

LIWP Measure	Energy Savings Reference
	OR Energy savings quantified using energy audit.
Solar PV	System production/energy savings will be quantified on a case-by-case basis using the PVWatts® Calculator. Available at: http://pvwatts.nrel.gov/
Thermostatic Shower Valve	eTRM Statewide Measure ID SWWH003-02. TSV with and without an Integrated Low-Flow Showerhead, Residential. EUL ID: WtrHt-WH-Shrhd. Available at: https://www.caetrm.com/measure/SWWH003/02/
Thermostatic Shower Valve and Showerhead	eTRM Statewide Measure ID SWWH003-02. TSV with and without an Integrated Low-Flow Showerhead, Residential. EUL ID: WtrHt-WH-Shrhd. Available at: https://www.caetrm.com/measure/SWWH003/02/ OR Energy savings quantified using energy audit.
Tier 2 Audio-Visual Advanced Power Strips (T-2 AV APS)	eTRM Statewide Measure ID SWAP010-01. Smart Connected Power Strip. EUL ID: Res-Plug-AdvPwrStrip. Available at: https://www.caetrm.com/measure/SWAP010/01/
Vacancy Sensors	PG&E Energy Savings Assistance (ESA) Program Annual Report for Program Year 2015, May 1, 2014. ESAP Table 9. Available at: http://docs.cpuc.ca.gov/PublishedDocs/Efile/G000/M164/K883/164883950.PDF
Wall Insulation	eTRM Statewide Measure ID SWBE007-01. Wall Insulation, Residential. EUL ID: BS-BlowInIns. Available at: https://www.caetrm.com/measure/SWBE007/01/ OR Energy savings quantified using energy audit.
Water Heater Blanket	Evaluation, Measurement, and Verification Report for the Moderate Income Comprehensive Attic Insulation Program #1082-04, Study ID:BOE0001.01. June 12, 2008.

LIWP Measure	Energy Savings Reference
	Available at: http://www.calmac.org/publications/BO MICAP 1082 04 E MV FINAL Report BOE000101.pdf
Water Heater (tank type >75k Btu/hr)	eTRM Statewide Measure ID SWWH011-02 Available at: https://www.caetrm.com/measure/SWWH011/02/ OR Energy savings calculated by energy audit tool
Water Heater (tank type <75k Btu/hr)	eTRM Statewide Measure ID SWWH012-02 Available at: https://www.caetrm.com/measure/SWWH012/02/ OR Energy savings calculated by energy audit tool
Water Heater (tankless)	eTRM Statewide Measure ID SWWH013-02 Available at: https://www.caetrm.com/measure/SWWH013/02/ OR Energy savings calculated by energy audit tool
Whole House Fan	eTRM Statewide Measure ID SWHC030-03. Whole House Fan, Residential. EUL ID: HV-WHfan. Available at: https://www.caetrm.com/measure/SWHC030/03/

Table 7. Data Sources for Individual Deemed Measures Restricted to Multi-family Dwellings

LIWP Measure	Energy Savings Reference
Boiler (heating)	eTRM Statewide Measure ID SWHC004-04 Available at: https://www.caetrm.com/measure/SWHC004/04/ OR Energy savings quantified using energy audit.
Central Boiler Temperature Controller	eTRM Statewide Measure ID SWWH024-02 Found at: https://www.caetrm.com/measure/SWWH024/02/ OR Energy savings quantified using energy audit.
Domestic Hot Water Recirculation System Upgrades – Time, Temperature, or Demand Control	eTRM Statewide Measure ID SWWH015-03 Found at: https://www.caetrm.com/measure/SWWH015/03/ OR Energy savings quantified using energy audit.
Heat Pump Water Heater (in-unit, fuel sub)	eTRM Statewide Measure ID SWWH025-05 Found at: https://www.caetrm.com/measure/SWWH025/05/ OR Energy savings quantified using energy audit.
Heat Pump Water Heater (central, fuel sub)	eTRM Statewide Measure ID SWWH025-05 Found at: https://www.caetrm.com/measure/SWWH025/05/ OR Energy savings quantified using energy audit.
Heat Pump Water Heater (residential, serving common areas)	eTRM Statewide Measure ID SWWH027-03 Found at: https://www.caetrm.com/measure/SWWH027/03/ OR Energy savings quantified using energy audit.
Heat Pump HVAC (Common Area)	eTRM Statewide Measure ID SWHC046-02 Found at: https://www.caetrm.com/measure/SWHC046/02/ OR Energy savings quantified using energy audit.
Mini-Split Heat Pump	eTRM Statewide Measure ID SWHC044-02 Found at: https://www.caetrm.com/measure/SWHC044/02/ OR eTRM Statewide Measure ID SWHC045-01 Found at: https://www.caetrm.com/measure/SWHC045/01/ OR

LIWP Measure	Energy Savings Reference
	eTRM Statewide Measure ID SWHC050-02 Found at: https://www.caetrm.com/measure/SWHC050/02/ OR Energy savings quantified using energy audit.
Pipe Insulation (for central DHW)	ETRM Statewide Measure ID SWWH026-02 Found at: https://www.caetrm.com/measure/SWWH026/02/
Pipe Insulation (for heating)	ETRM Statewide Measure ID SWWH017-04 Found at: https://www.caetrm.com/measure/SWWH017/04/ OR Energy savings quantified using energy audit.
Pool Cover	eTRM Statewide Measure ID SWRE001-01 Found at: https://www.caetrm.com/measure/SWRE001/01/ OR Energy savings quantified using energy audit.
Pool Heater	eTRM Statewide Measure ID SWRE003-03 Found at: https://www.caetrm.com/measure/SWRE003/03/ OR Energy savings quantified using energy audit.
Pool Heater (heat pump)	eTRM Statewide Measure ID SWRE005-02 Found at: https://www.caetrm.com/measure/SWRE005/02/ OR Energy savings quantified using energy audit.
Pool pump (DC)	eTRM Statewide Measure ID SWRE002-01 Found at: https://www.caetrm.com/measure/SWRE002/01/ OR Energy savings quantified using energy audit.
Variable Speed Pool Pump	eTRM Statewide Measure ID SWRE002-01 Found at: https://www.caetrm.com/measure/SWRE002/01/ OR Energy savings quantified using energy audit.
Vending Machine Controller	eTRM Statewide Measure ID SWAP011-03 Found at: https://www.caetrm.com/measure/SWAP011/03/

Table 8. Data Sources for Snugg Pro

Reference Source	Website
30 Year Weather Normals by the National Climatic Data Center (NCDC)	https://www.ncdc.noaa.gov/data-access/land-based-station-data/land-based-datasets/climate-normals/1981-2010-normals-data
Current Weather data by NCDC Quality Controlled Data	https://www.ncdc.noaa.gov/crn/qcdatasets.html
Electricity prices by utility (EIA + geo-referencing)	https://www.eia.gov/electricity/monthly/epmta_table_grapher.php?t=epmt_5_6_a
EnergyStar certified appliance tables (EnergyStar)	https://www.energystar.gov/productfinder/
IECC 2006 standards based on climate zone (IECC)	https://www.iccsafe.org/errata-central/
National city/state/zip cross-referencing	https://catalog.data.gov/dataset/zip-codes-zipcodes
National database of improvement costs and specifications (National Residential Efficiency Measures Database, NREL)	https://remdb.nrel.gov/
Natural gas, fuel oil, and propane price by state (EIA)	https://www.eia.gov/dnav/ng/ng_pri_sum_dcunus_m.htm https://www.eia.gov/petroleum/heatingoilpropane/#itn-tabs-1
National emissions per kWh database by utility (eGrid, EIA, EPA, CARMA)	https://www.epa.gov/energy/emissions-generation-resource-integrated-database-egrid https://www.eia.gov/electricity/data.php
Regional and age specific default housing characteristics (NREL and LBL)	http://www.homeenergysaver.lbl.gov/consumer/documentation
Regional comparable average home energy consumption (Residential Energy Consumption Survey, RECS)	https://www.eia.gov/consumption/residential/data/2015/index.php?view=consumption
Typical Meteorological Year (TMY) by the National Renewable Energy Laboratory	https://rredc.nrel.gov/solar/old_data/nsrdb/1991-2005/tmy3/

Table 9. Data Sources for EnergyPro

Reference Source	Website
2016 Building Energy Efficiency Standards (CEC-400-2015-037-CMF, June 2015)	https://www.energy.ca.gov/title24/2016standards/
ASHRAE Publications (ASHRAE Handbook of Fundamentals, ASHRAE 90.1 Performance Compliance, etc.)	https://www.ashrae.org/technical-resources/ashrae-handbook
Department of Energy (DOE) EnergyPlus Program	https://energyplus.net/
Reference Appendices for the 2016 Building Energy Efficiency Standards (CEC-400-2015-038-CMF, June 2015)	https://www.energy.ca.gov/2015publications/CEC-400-2015-038/
Residential Alternative Calculation Methods (ACM) Reference Manual (CEC-400-2015-024-CMFREV, 2008 and Revised June 2016)	https://www.energy.ca.gov/2015publications/CEC-400-2015-024/ https://www.energy.ca.gov/title24/2008standards/
Residential Compliance Manual (CEC-400-2015-032-CMF, November 2015)	https://www.energy.ca.gov/2015publications/CEC-400-2015-032/