California Air Resources Board

Greenhouse Gas Quantification Methodology for the Department of Community Services and Development Low-Income Weatherization Program - Large Multi-Family Greenhouse Gas Reduction Fund Fiscal Year 2014-15

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A. Introduction

The California Air Resources Board (ARB) is responsible for providing the quantification methodologies to estimate greenhouse gas (GHG) emission reductions from projects receiving monies from the Greenhouse Gas Reduction Fund (GGRF). ARB staff developed the quantification methodologies outlined in this document to be used by the Department of Community Services and Development (CSD) to estimate GHG emission reductions from Low-Income Weatherization Program - Large Multi-Family (LIWP-LMF) projects for Fiscal Year (FY) 2014-15 funds. The quantification methods provide estimated emission reductions from the following project types for large multi-family:

- Weatherization / Energy Efficiency
- Solar Water Heaters (SWH)
- Solar Photovoltaics (PV)

Methodology Development

For the first year (FY 2014-15) of LIWP-LMF, ARB and CSD staff followed a set of principles to guide the development of the quantification methodology.

The methodology must:

- Apply at the project-level, for project types being funded by LIWP-LMF.
- Provide uniform methods that can be applied statewide.
- Estimate GHG emission reductions from the projected energy savings achievable through weatherization and renewable energy projects installed.
- Use existing and proven tools or methodologies that are supported by empirical literature where available.

The methodologies provide a uniform approach to estimate energy savings, in electricity (kWh) and natural gas (therms), and GHG emission reductions, which are reported in metric tons of carbon dioxide equivalent ($MTCO_2e$), from large multi-family building weatherization and renewable energy projects. A summary of the project types and quantification methods are provided in Table 1.

Table 1: Summary of GHG Reduction Projects and Quantification Methodologies

Project Type	Methods	Emission Factor	GHG Reductions
Weatherization / Energy Efficiency	Performance Approach: Energy Assessment Tools	Electricity and Natural Gas	$MTCO_2e$
Solar Water Heater (SWH)	CSI Solar Thermal Calculator	Electricity or Natural Gas	$MTCO_2e$
Solar Photovoltaics (PV)	PVWatts Calculator	Electricity	$MTCO_2e$

GHG Emission Reductions

This methodology estimates the GHG emission reductions of proposed CSD projects based on the estimated energy savings due to the installation of weatherization, solar water heaters, and solar PV at large multi-family buildings.

CSD will estimate the total GHG emission reductions from the program as a whole and by project type, for all program providers, as defined in the methodology and report results as:

$$\frac{Total\ Program\ GHG\ Emission\ Reduction\ in\ Metric\ Tons\ (MT)\ of\ CO_2e}{GGRF\ LIWP - LMF\ FY\ 2014 - 15\ Funds\ (\$)}$$

Program providers will report GHG emission reductions per GGRF Funds requested by project type per building and by whole LMF building as described in Section C. The following section describes the calculations needed to estimate the GHG emission reductions for proposed projects under the FY 2014-15 CSD LIWP-LMF Program.

B. Quantification Methodology

This methodology estimates the GHG emission reductions of proposed CSD LIWP-LMF projects based on estimated energy savings.

The following is a summary of the methods by project type.

Weatherization / Energy Efficiency

Weatherization of large multi-family buildings applies a whole-building approach to assessing the building for energy inefficiencies, in order to identify and implement the appropriate upgrades or repairs to improve the overall energy efficiency of the building. A weatherized large multi-family building in California will reduce GHG emissions by reducing electricity and natural gas consumption. The weatherization quantification methodologies described in this document pertain only to large multi-family buildings. Large multi-family buildings are defined in CSD's LIWP-LMF Program Guidelines.[1]

The "Project Case"

The project case represents the estimated GHG emission reductions expected to occur for a single LMF building after the weatherization measures are implemented. The first step in calculating the project case is conducting a large multi-family whole building energy assessment. The assessment evaluates the large multi-family building's enclosure or "thermal boundary" and the interactive effects of all energy related systems to identify potential sources of inefficiencies. The large multi-family building energy

[1] Low-Income Weatherization Program Guidelines. (2015, November 10). Available online at: http://www.csd.ca.gov/Portals/0/Documents/LIWP/LIWP%20LMF%20Final%20Program%20Guidelines%20111015%20FINAL.pdf

assessment is designed to generate a list of recommended performance improvement measures that advance the energy efficiency of the large multi-family building, which subsequently reduces GHG emissions.

LIWP-LMF Weatherization services to a particular large multi-family building will use a performance approach for calculating the energy savings and the Savings to Investment Ratio (SIR) of all measures. This approach will be used to determine the scope of work for each building.

The performance approach utilizes a site-specific energy audit and energy model to assess energy savings measures based on cost-effectiveness. The anticipated energy savings for the project case utilizes an energy assessment or energy audit tool methodology described below.

Performance Approach: Energy Assessment Tool

Energy assessment tools are used as part of the performance approach to determine the energy performance of the large multi-family building and identify opportunities for energy efficiency improvements. The energy assessment tools utilize specialized software to determine the large multi-family building's energy load and estimate energy consumption based on data points collected about the building's geometric characteristics, thermal boundary, location, number of dwellings, and energy systems.

There are many large multi-family building energy assessment tools in the marketplace. These tools may vary considerably in how they collect and analyze a large multi-family building's characteristics and generate energy efficiency improvement recommendations.[2] The LIWP-LMF program will use energy assessment software tools approved by the California Energy Commission (CEC)[3] or Energy Upgrade California (EUC)[4] for compliance with energy efficiency programs.

Providers should estimate GHG emission reductions from calculated energy savings utilizing the energy assessment tools per LMF building as follows:

$$GHG_{electricity} = EA_{electricity} \; x \; EF_{electricity} \qquad \text{Eq. 1}$$

$$GHG_{natural\ gas} = EA_{natural\ gas} \; x \; EF_{natural\ gas} \qquad \text{Eq. 2}$$

$$GHG_{total} = GHG_{electricity} + GHG_{natural\ gas} \qquad \text{Eq. 3}$$

[2] Review of selected home energy auditing tools, DOE. (2010, November 2). Available online at http://apps1.eere.energy.gov/buildings/publications/pdfs/homescore/auditing_tool_review.pdf

[3] List of approved CEC energy audit software is available online at: http://www.energy.ca.gov/title24/2013standards/2013_computer_prog_list.html

[4] List of approved EUC energy audit tools is available online at: http://www.caltrack.org/caltest.html

$$GHG_{life\ building} = GHG_{total}\ x\ Life \qquad \text{Eq. 4}$$

Where:

- EA $_{electricity}$ = annual estimated energy assessment savings from electricity of all measures installed (kWh)
- EF $_{electricity}$ = emission factor for electricity (0.000315 $MTCO_2e$ per kWh)[5]
- GHG $_{electricity}$ = annual GHG emissions reduced from electricity ($MTCO_2e$)
- EA $_{natural\ gas}$ = annual estimated energy assessment savings from natural gas of all measures installed (therms)
- EF $_{natural\ gas}$ = emission factor for natural gas (0.005311 $MTCO_2e$ per therm)[6]
- GHG $_{natural\ gas}$ = annual GHG emissions reduced from natural gas ($MTCO_2e$)
- GHG $_{total}$ = sum of annual GHG emissions reduced from electricity and natural gas ($MTCO_2e$)
- Life = estimated average lifetime of measures installed. The average lifetime can be determined utilizing the Database for Energy Efficiency Resources (DEER)[7] database effective useful life (EULs) for each measure installed (years). DOE EULs may be used when DEER EULs for measures are not identified, or in certain cases, when EULs for measures are appropriate and justifiable.
- GHG $_{life\ building}$ = lifetime GHG emissions reduced per large multi-family building ($MTCO_2e$)

Solar Water Heater

Solar water heaters (SWH) use radiant heat from the sun to heat either water or a heat-transfer fluid in a roof mounted collector.[8] SWH systems typically provide 60 percent of the hot water needed by an end-user, with the remainder provided by a back-up water heater powered by natural gas or electricity.[9] The most common applications for SWH systems are for direct hot water uses in the large multi-family building such as showers, dishwashers, and clothes washing machines.

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[5] For the purposes of GGRF quantification methodologies, ARB developed a California grid electricity emission factor based on total in-state and imported electricity emissions ($MTCO_2e$) divided by total consumption in MWh. Emissions from ARB GHG inventory (2012), available online at: http://www.arb.ca.gov/cc/inventory/data/tables/ghg_inventory_by_sector_00-12_sum_2014-03-24.pdf. Consumption data from CEC Energy Almanac (2012), available online at: http://energyalmanac.ca.gov/electricity/electricity_generation.html

[6] EPA Emission Factors for Greenhouse Gas Inventories. (2014, April 4), available online at: http://www.epa.gov/climateleadership/documents/emission-factors.pdf

[7] DEER is a CEC and CPUC sponsored database available online at: http://www.energy.ca.gov/deer/

[8] CPUC Energy Division

[9] CPUC Energy Division – CSI Thermal Program

The “Project Case”

The project case represents the estimated GHG emissions expected to occur after SWH installation in a single LMF building. The CSI solar thermal calculators will be used for estimating the project case for SWH projects. The CSI solar thermal calculators are online calculation tools that provide an estimate of the energy displacement for SWH systems based upon performance of the SWH system, location, and system design. For large multi-family building projects that install SRCC OG-300 rated systems, utilize the CSI single-family solar thermal calculator[10] if eligible equipment guidelines are met as described in the CSI Solar Thermal Handbook. For large multi-family building projects that install SRCC OG-100 rated systems, utilize the CSI multi-family/commercial solar thermal calculator.[11] Both of the CSI Solar Thermal Calculators estimate the annual energy savings value of the systems for all locations in California.

The CSI single-family solar thermal calculator inputs needed are:

- Standard 300 system type
- Site zip code
- Backup water heater type
- Azimuth
- Tilt
- Annual average access – (average annual percentage of access to sun from this solar array from 10:00 am – 3:00 pm PST[12])
- Gas utility service provider
- Electric utility service provider

The CSI multi-family/commercial solar thermal calculator inputs needed are:

- Heat exchanger
- Freeze protection
- Overheat protection
- Tank configuration
- Collector
- Number of collectors
- Average collector module area
- Total collector area

[10] CSI Thermal Program Incentive Calculator for Standard-300 Systems. Available online at https://www.csithermal.com/calculator

[11] CSI Thermal Commercial and Multifamily Residential Incentive Calculator. Available online at https://www.csithermal.com/calculator/commercial

[12] Refer to section 2.3 of the CSI solar thermal handbook for more information.

- Number of collectors in series per flow path
- Total solar storage capacity
- Total number of solar tanks
- Total backup storage capacity
- Total number of backup tanks
- Backup fuel source
- Maximum auxiliary heat capacity
- CEC climate zone
- Building type
- Hot water demand (gallons per day)
- Recirculation loop
- Set point temperature of backup
- Tracking
- Array tilt
- Array azimuth
- Annual average access – (average annual percentage of access to sun from this solar array from 10:00 am – 3:00 pm PST[13])
- Project name

The SWH annual system savings results (kWh or therms) from the CSI solar thermal calculator will be used to estimate the annual GHG emission reductions ($MTCO_2e$) per LMF building as follows:

$$GHG_{life} = \sum_{n=1}^{n=x} \left[1-(n)\left(R_{degradation}\right)\right]\left(SWH_{savings}\right)(EF) \qquad \text{Eq. 5}$$

Where:

- n = number of years
- x = length of manufacturer warranty (years)
- $R_{degradation}$ = rate of system degradation (0.5% per year[14])
- $SWH_{savings}$ = annual estimated system savings from CSI solar thermal calculator (kWh or therms)
- EF = emission factor; electricity (0.000315 $MTCO_2e$ per kWh), natural gas (0.005311 $MTCO_2e$ per therm)
- GHG_{life} = total GHG emissions reduced from SWH system ($MTCO_2e$)

[13] Refer to section 2.3 of the CSI solar thermal handbook for more information.
[14] NRELTechnical Report (2011). "Break-even Cost for Residential Solar Water Heating in the United States: Key Drivers and Sensitivities. Available online at: http://www.nrel.gov/docs/fy11osti/48986.pdf

Solar Photovoltaics

A Solar Photovoltaics (PV) system is a renewable energy system that generates electricity directly from sunlight via an electronic process that occurs naturally in semiconductors. Electrons in semiconductors are released by solar energy and can be induced to travel through an electrical circuit, powering electrical devices, homes, buildings, or sending the electricity to the grid.

The "Project Case"

The project case represents the estimated GHG emissions expected to occur after solar PV installation in a single LMF building. Several solar PV calculators have been developed that identify annual solar PV output based on specific system type, inverter type, system size, location, etc. The NREL PVWatts calculator[15] is the methodology that will be used to estimate electricity savings from LIWP-LMF solar PV installations.

NREL's PVWatts Calculator is a web application developed by the National Renewable Energy Laboratory that estimates the electricity production of a grid-connected roof- or ground-mounted photovoltaic system based on a few simple inputs. To use the calculator, information is provided about the system's location, basic design parameters, and system economics. PVWatts calculates estimated values for the system's annual and monthly electricity production, and for the monetary value of the electricity.

The PVWatts calculator inputs needed are:

- Location
- DC system size (kW)
- Module type
- Array type
- System losses (%)
- Tilt
- Azimuth
- Note: "Loss Calculator" includes the following
    - Soiling (%)
    - Shading (%)
    - Snow (%)
    - Mismatch (%)
    - Wiring (%)
    - Connections (%)
    - Light induced degradation (%)
    - Nameplate rating (%)
    - Age (%)

[15] National Renewable Laboratory PVWatts Calculator. Available online at http://pvwatts.nrel.gov/

- Availability (%)

- NOTE: “Advanced Parameters” includes the following
  - DC to AC size ratio
  - Inverter efficiency
  - Ground coverage ratio

The solar PV annual generation results (kWh) from PVWatts calculator will be used to estimate the annual GHG emission reductions ($MTCO_2e$) per LMF building as follows:

$$GHG_{life} = \sum_{n=1}^{n=x} \left[1 - (n)\left(R_{degradation}\right)\right]\left(PV_{production}\right)\left(EF_{electricity}\right) \qquad \text{Eq. 6}$$

Where:

- n = number of years
- x = length of manufacturer warranty
- $R_{degradation}$ = rate of system degradation
- $PV_{production}$ = annual estimated kWh generated by solar PV calculator
- $EF_{electricity}$ = emission factor for electricity (0.000315 $MTCO_2e$ per kWh)
- GHG_{life} = total GHG emissions ($MTCO_2e$) reduced from solar PV system

C. Reporting and Documentation

The final step to complete this quantification methodology is to report the Total GHG Emission Reductions and provide documentation of the calculations.

Reporting

CSD will estimate the total GHG emission reductions from the program as a whole and by project type, for all program providers, as defined in the methodology and report results as:

$$\frac{Total\ Program\ GHG\ Emission\ Reduction\ in\ Metric\ Tons\ (MT)\ of\ CO_2e}{GGRF\ LIWP - LMF\ FY\ 2014 - 15\ Funds\ (\$)}$$

Program providers will report GHG emission reductions per GGRF Funds requested by project type per building and by whole LMF building.

Documentation

CSD is required to capture and retain documentation that is complete and sufficient to allow the quantification calculations to be reviewed and replicated.

Documentation will include:

- Contact information for the person who can answer project specific questions from staff reviewers on the quantification calculations;
- Project specific data inputs for weatherization, SWH, and solar PV;

- Quantification methodologies utilized;
- Estimated energy savings per large multi-family whole building and by project type per whole building;
- Project specific equipment specifications and certifications;
- Summary page with, at a minimum, the following information:
    - Total GHG emission reductions from the program as a whole and by project type over the project life
    - GHG emission reductions per large multi-family whole building and by project type per whole building
    - GGRF funds requested

ARB will continue to evaluate and update the GHG emission reduction quantification methodologies as necessary for future FY GGRF appropriations. Quantification methods are posted on ARB's auction proceeds webpage at: http://www.arb.ca.gov/cc/capandtrade/auctionproceeds/quantification.htm
Questions on this document should be forwarded to GGRFProgram@arb.ca.gov