**Southern California Regional Energy Network**

**Public Agency NMEC Program**

**Measurement & Verification Plan**

**DRAFT**

The purpose of this Measurement & Verification (M&V) Plan document is to serve as an appendix to the Implementation Plan for the Southern California Regional Energy Network’s (SoCalREN) Public Agency NMEC Program.

Early in the engagement process with the participant, the Program will document participant needs and barriers to implementing the project. In addition, the program will provide a range of services critical to the identification and implementation of these projects, including: site audits, measure recommendations, financial analysis, and information on equipment selection assistance. The Program will also screen projects to minimize free ridership issues by ensuring program intervention in the early stages of project planning and selecting out projects with little opportunity for program influence. This combination of strategies will help to demonstrate to the California Public Utilities Commission (CPUC) how the program will manage and reduce the risks associated with Program free ridership. The Program will serve two main facility types: Whole Buildings and Street lighting/Exterior Lighting. To take into consideration these different end uses, the Measurement & Verification (M&V) Plan for each facility type has been addressed separately in this document.

**M&V Plan for Whole Buildings**

An ASHRAE Level 1 audit conducted by this Program or through other entities at participating facilities will be used to identify the individual energy efficiency measures and forecasted metered energy savings. The program will cross-reference these measures with the IOUs to prevent double-dipping with upstream, midstream and downstream Programs. The total identified project energy savings will be used to determine if it constitutes at least 10% of the facility’s annual consumption. If so, cost estimates will be used to develop a financial proposal to get customer buy-in for all of the measures identified. These measure savings will be used to determine a weighted average of Effective Useful Lives (EULs) to provide an NMEC-level EUL on a project basis. Since the metering (i.e. whole building utility meter) will be left in place, it is anticipated that *ex‐post* EM&V will benefit from these *ex-ante* calculations as a foundation to determine an appropriate EUL for NMEC approaches.

**Methodology**

After it is determined that the facility has at least 10% savings, a Normalized Metered Energy Consumption (NMEC) approach will be used to quantify savings at the meter. This approach follows that which was originally described in the industry-standard International Measurement & Verification Protocol (IPMVP) as Option C Whole Building [*to be included in final draft as appendix*]. Using this approach, energy use and independent variable data is collected throughout the baseline, installation, and post-installation periods. Empirical, or data-driven methods, are used to develop models that show mathematically how the independent variables influence energy use. Baseline models are developed from baseline period data, and post-installation models are developed from post-installation period data. 12 months each of baseline and post-installation data must be collected and used to develop the models.

**Baseline Assumptions**

Following are some of the baseline assumptions used for the methodology:

* Time series energy use data is available for the requisite time periods for the buildings participating in this program
* Ambient temperature and building schedule will explain the dominant portion of the variation in building energy use.
* Building operation schedules are available from the building energy managers, or are detectable from the time series energy use data
* CPUC approved climate zone reference data in addition to Actual Meteorological Year (AMY) weather data for the nearest weather station

**Data Collection Plan**

Baseline and post-installation energy use data will be collected at the meter level for the utility. The data will be collected in the most granular form available, such as 15-minute intervals for electric energy use, and ideally hourly (otherwise monthly) data for natural gas use. Data for buildings served by chilled or hot water, or steam from a central plant will also be collected at the most time-granular interval available.  
  
Weather data will be collected from the nearest National Oceanic and Atmospheric Administration (NOAA) weather station that also has long-term TMY weather data available. Simultaneously, the implementer assumes that the CPUC will produce a reference weather data set for NMEC purposes. As a parallel approach the implementer will also collect the most current AMY data from sources considered industry standard[[1]](#footnote-1).This is critical for normalizing and calibrating energy patterns to *actual* meteorological weather observations, as opposed to averaged or *typical* observations in TMY data.  
  
The data will be assessed for gaps and outliers. Data gaps will be filled by the best method available, which may include interpolation or comparison with similar days for all the input data received. Data preparation activities will be fully documented in the savings report.

**Modeling**  
The baseline and post-installation modeling algorithms are regressions based on change-point models originally developed under ASHRAE Research Project 1050. Change-point models are a series of dependent piecewise linear relationships between energy use and ambient temperature. The change-point models are named by the number of parameters in the model and whether they apply to heating or cooling energy use. After each model is developed, the change-points and coefficients of the slopes of each line segment will have been determined, along with their goodness-of-fit-metrics. See ASHRAE RP1050 for change-point modeling details.  
  
To facilitate development of energy models, the data may be grouped into different bins based on the building operating periods. Such bins may include occupied or unoccupied periods, weekdays, weekends, or holidays, or in-session versus out of session periods, as are common in schools and universities. Thus, different models may be developed in the baseline period according to these unique operation periods, as they will have different responses to ambient temperature. After acceptable models are developed for each period, they may be combined using an indicator variable. This approach applies to both baseline and post-installation period data.  
  
In order to achieve acceptable models, the baseline and post-installation models are required to meet the goodness-of-fit criteria described below:

1) The coefficient of variation of the root mean squared error (a measurement of the random error of the model) CV(RMSE) < 25%.

2) The net determination bias error (a measurement of the model’s bias error) NDBE < 0.005%  
3) The coefficient of determination (a measure of how well the independent variables explain the dependent or energy use variable) R2 > 0.75.

Definitions of these metrics may be found in ASHRAE Guideline 14-2014.  
  
At the end of the post-installation period, both baseline and post-installation models will be normalized using the nearest typical meteorological year (TMY) weather conditions for the building’s climate zone. Both baseline and post-installation models will be ‘normalized’ to TMY conditions. The difference between the total normalized *baseline* energy use and the total normalized *post-installation* energy use will define the total normalized savings. The normalized savings will be claimed as the savings for the measures installed in each participating building.

**Identifying and Adjusting for Non-Routine Events**  
Non-routine events (NRE) are events unrelated to weather, normal operation, and energy efficiency measures that impact energy use. NREs can include changes in building occupancy, equipment shut-downs, major renovations such as changes in facility size, or a steady increase in building loads due to factors such as the addition of personal heaters, electric vehicle charging capabilities, or and addition of onsite renewable energy generation. The potential for NREs occurring during an NMEC project is not insignificant and continuous customer contact, ongoing monitoring of the building, and frequent comparison to the predicted building performance, are necessary to detect them. When NREs occur, it is necessary to determine whether they add load (reduce savings) or decrease load (increase savings), how significant they are, and how to properly quantify them.

Program participants shall be responsible for notifying the program of any NREs, which would include a detailed narrative describing the changes that have occurred and the duration of the NRE. Depending on their significance, NRE impacts on building energy use will be quantified using engineering calculations supported by audit information and/or measured energy use data, or directly from the building’s metered energy use data. Each NRE will be described, and the methodology for quantifying their impacts, data, and analysis, provided with the final savings report.

**Savings Risk Management**

The Program will screen for site-level projects that have an *ex-ante* savings higher than 10% of annual consumption. However, it is possible that the *ex post* savings might be less than 10%. The main reason for that is the risk of customers not installing all the measures identified in an audit or not installing the measures as planned. The Program will make sure that there is commitment from the customer to install measures as proposed and to ensure that the customers understand the risks of not doing so. The Program will stay connected with the customer to reduce this risk. The Program will also ensure that the *ex-ante* savings calculations are conservative. In the event that the project site savings turn out to be less than 10% of annual consumption, potential reasons for this shortfall would be investigated.

The four main reasons for projects falling below the 10% threshold are as follows:

1. One or more of the measures were not installed
2. One or more of the measures were not installed as planned
3. Unidentified NRE
4. The *ex-ante* savings were not calculated correctly

For the first two reasons, the disaggregated measure savings and adjustments would be used to reconcile the difference between the actual and expected savings. This may also be accompanied by site visits to verify the installations. If the measures were installed as expected, the potential of NREs that may have gone unnoticed or undetected would be discussed in length with the customer and a site visit may also be undertaken to look into the possible reasons. Finally, after exploring all the other reasons, the ex-ante savings calculations for each measure would be revisited and even different calculation approaches may be tried to reconcile the difference in savings.

**Methodology for Program Influence**

[To be included in final draft of implementation plan that will be uploaded to EEstats]

**Training (*Persistence of Savings*)**

The Program will work with the contractor and the customer to update the Operations and Maintenance (O&M) manual at the facility for the measures installed, or create a new one, if none exists. The O&M manual will contain the include a description of the implemented measures, including setpoints, sequences of operation, and system diagrams, as well as a plan to describe the resources and O&M requirements to maintain these measures. The O&M requirements would typically include a checklist of maintenance tasks and a schedule for performing them. Checklists are kept for each piece of equipment and updated after maintenance tasks are performed. On the operations side, it involves a planned schedule of regular review and updating of occupancy or operational changes and making sure those changes don’t impact the measures installed. Training will also be conducted with facility personnel on the use of the O&M manual. A check-in will also be conducted with facility staff every six months for a period of 2 years after installation to answer any questions or provide additional training, if required.

**Monitoring and Reporting Savings**

With the availability of Green Button Connect, this Program will constantly monitor 15-minute interval data and provide visibility to real-time energy savings. A “savings persistence” report will be created on a monthly basis for 3 years after the measures are installed to provide direct feedback to facility personnel that may not have visibility to utility bills.

These reports would include, but would not be limited to, the following information:

1. The baseline energy usage
2. Current energy usage
3. Annual savings
4. Energy and Cost Savings to-date
5. Any changes to predicted savings

This Program will present these reports to the customer facility staff so there is an understanding of how the information was collected and analyzed, and also to identify any potential NREs.

**Additional Reporting Details**

* The reporting period stage begins once the measures are installed, working and producing savings.
* Reporting period stage shall last no less than 12 months for capital projects and 24 months for projects containing behavior, retro commissioning, operational, maintenance and repair measures. Data being collected will be briefly verified 1 to 2 months into monitoring period to ensure appropriate monitoring is occurring, any necessary adjustments will be documented in the Final M&V Report.
* In addition to the review at four-months described above, projects will be monitored periodically for deviations from expected savings to identify and adjust for non-routine events. All adjustments should be documented in the Final M&V Report

**Final M&V Report**

* A Final M&V Report that documents the activities carried out per the M&V Plan.
* The Final M&V Report will document data collection (pre-and post-installation), adjustment models and all findings related to routine and non-routine events.
* The Final M&V Report will present the first year and lifecycle savings claims, final avoided energy use and final normalized energy savings.

**M&V Plan for Street lighting and Exterior Lighting**

A lighting schedule that may be obtained from the customer or a site visit would be used to estimate the baseline energy usage based on the fixture count, wattage, and DEER operating hours for the baseline lighting application and control. This usage would be compared with the energy usage at the meter to verify the fixture count, wattage and operating hours. If the difference is within +/-5%, it is reasonable to assume that the fixture count, fixture wattage and operating hour assumptions were accurate. The proposed energy usage, and thus, energy savings can now be estimated based on standard fixture replacement wattage and DEER operating hours reduction for any new controls installed. If the energy savings is at least 10% of the metered baseline energy usage, then this project would be considered a good candidate for the NMEC methodology.

**Baseline Assumptions**

The baseline assumptions for projects under this application include:

1. The baseline lighting fixtures operate at 100% power when operational.
2. The baseline lighting fixtures are controlled either by photocell or timeclock or both to operate only during dark hours.
3. The meter serving the baseline lighting is dedicated to that lighting, and has no additional loads, or no additional loads that exceed 5% of the total metered consumption.
4. All baseline fixtures are fully operational during the trending period.

**Data Collection Plan**  
To validate the savings from this project type, 12 months of pre-retrofit metered power consumption data and 12 months of post-retrofit power consumption data will be collected and compared. Data will be collected in the most granular form available, with 15-minute interval data preferred, though monthly data will likely be required for street lighting service accounts that do not have net-energy metering.   
  
Power consumption data will be collected for 12 months prior to project implementation and 12 months following final commissioning of the installed systems. Both trending periods shall cover both daylight savings time hours and non-daylight savings time hours.   
  
Photometric analysis will be conducted before and after project implementation. These analyses will be compared to ensure that post-retrofit lighting systems meet or exceed baseline lighting output or meet ANSI/IESNA RP-8 standards.   
  
Data shall be collected to identify and assess any non-routine events (NREs) that affect system operation.

This data will include:

1. Quarterly review of programmed timeclock schedules
2. Quarterly check-in meetings with city staff to catalog any outages, instances of burned-out fixtures, or changes to operating schedules.

**Modeling**

In the absence of any non-routine events (NREs), the total energy savings will be defined as the difference between the total baseline energy consumption and the total post-retrofit energy consumption. In general, the baseline and post-retrofit systems will operate under the same constraints, namely that the light fixtures will operate only during dark hours. Since these constraints do not vary from year-to-year and there are no other factors that influence energy use such as ambient temperature, no additional normalization will be necessary. In this situation, the energy savings will be defined by the following formula:

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| --- |
| Annual Energy Savings (kWh/yr) = Baseline Metered Energy Consumption (kWh/yr) - Post Retrofit Metered Energy Consumption (kWh/yr) |

If, however, any NREs are identified that result in different post-retrofit operating hours compared to baseline hours, then the dataset will be normalized to the baseline operating hours. In such a case, the post-retrofit data will be normalized to the baseline hours using this simple formula:

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| Normalized Post Retrofit Energy Consumption (kWh/yr) = Baseline Operating Hours (hrs/yr)x (Post Retrofit Metered Energy Consumption (kWh/yr))/(Post Retrofit Operating Hours (hrs/yr) ) |

And the energy savings will then be calculated using the following formula:

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| Annual Energy Savings (kWh/yr) = Baseline Energy Consumption (kWh/yr) -Normalized Post Retrofit Metered Energy Consumption (kWh/yr) |

**Savings Risk Management**

This section will follow the approach outlined in the Whole Building M&V section.

**Training (*Persistence of Savings*)**

The Program will work with the contractor and the customer to update the Operations and Maintenance (O&M) manual at the facility for the measures installed, or create a new one, if none exists. The O&M manual will include a description of the implemented measures, and O&M requirements to maintain these measures. The O&M requirements would typically include a checklist of maintenance tasks and a schedule for performing them. Checklists are kept for each piece of equipment and updated after maintenance tasks are performed. On the operations side, it involves a planned schedule of regular review and updating of operational changes and making sure those changes don’t impact the measures installed. Training will also be conducted with facility personnel on the use of the O&M manual.

With the availability of Green Button connect, this Program will provide data services similar to the services outlined in the Whole Building project.

1. One such example is Whitebox Technologies, an industry expert and former DOE / National Lab staff member that now provides AMY data for the energy modeling and simulation community across the world. [↑](#footnote-ref-1)