E. Measurement & Verification

The long-term success of any comprehensive energy efficiency program depends on the development of an accurate, successful M&V plan. The objective is to develop plan that is cost effective, yet sufficiently quantifies and verifies the performance of the ECMs. Ameresco normally adheres to industry standard M&V protocols that have been developed in response to the need for reliable and consistent measurement practices. The reference used for the development of M&V procedures for this project is Efficiency Valuation Organization's International Performance Measurement & Verification Protocol (IPMVP).

The protocols also help to allocate various risks associated with achieving energy cost savings and allow for risk reduction. The M&V options description, provided herein, was developed by summarizing the International Performance Measurement and Verification Protocol and contains excerpts taken from that document. The benefits of the protocols are as follows:

- Defines the role of verification in energy contracts and implementation.
- Discusses procedures, with varying levels of accuracy and cost, for verifying baseline and project installation conditions and long-term energy savings performance.
- Provides techniques for calculating whole-facility savings, individual technology savings, as well as stipulated savings.
- Provides procedures that are consistent, industry accepted, impartial, and reliable.
- Provides procedures for the investigation and resolution of disagreements related to performance issues.

The general approach to determining energy savings in these plans involves comparing the energy use of the retrofitted system before installation of the ECM (baseline) and after installation of the ECM (post-retrofit).

- In general: Energy Savings = Baseline Energy Use – Post Retrofit Energy Use

The IPMVP protocols have defined four M&V options (Options A through D) that meet the needs of a wide range of performance contracts and provide suggested procedures for baseline development and post-retrofit verification. There is an additional category by Ameresco as Stipulated (Option S). This option is reserved for ECMs with relatively small savings values, or ECMs that are difficult to accurately measure. The Stipulated option is often used when the cost to measure a particular ECM would greatly diminish the savings associated with it. The table below summarizes the IPMVP standards.

IPMVP Summary Table

M&V Option	How Savings Are Calculated	Typical Applications
Option A: Partially Measured Retrofit Isolation		
Savings are determined by partial field measurement of the energy use of the system(s) to which an ECM was applied, separate from the energy use of the rest of the facility. Measurements may be either short-term or continuous.	Engineering calculations using short term or continuous post-retrofit measurements and stipulations.	Lighting retrofit where power draw is measured periodically. Operating hours of the lights are assumed to be one half hour per day longer than store open hours.
Partial measurement means that some but not all parameter(s) may be stipulated, if the total impact of possible stipulation error(s) is not significant to the resultant savings. Careful review of ECM design and installation will ensure that stipulated values fairly represent the probable actual value. Stipulations should be shown in the M&V Plan along with analysis of the significance of the error they may introduce.		
Option B: Retrofit Isolation		
Savings are determined by field measurement of the energy use of the systems to which the ECM was applied, separate from the energy use of the rest of the facility. Short-term or continuous measurements are taken throughout the post-retrofit period.	Engineering calculations using short term or continuous measurements	Application of controls to vary the load on a constant speed pump using a variable speed drive. Electricity use is measured by a kWh meter installed on the electrical supply to the pump motor. In the base year this meter is in place for a week to verify constant loading. The meter is in place throughout the post-retrofit period to track variations in energy use.
Option C: Whole Facility (Bill Comparison)		
Savings are determined by measuring energy use at the whole facility level. Short-term or continuous measurements are taken throughout the post-retrofit period.	Analysis of whole facility utility meter or sub-meter data using techniques from simple comparison to regression analysis.	Multifaceted energy management program affecting many systems in a building. Energy use is measured by the gas and electric utility meters for a twelve month base year period and throughout the post-retrofit period.
Option D: Calibrated Simulation (Calibrated Building Modeling)		
Savings are determined through simulation of the energy use of components or the whole facility. Simulation routines must be demonstrated to adequately model actual energy performance measured in the facility. This option usually requires considerable skill in calibrated simulation.	Energy use simulation, calibrated with hourly or monthly utility billing data and/or end- use metering.	Multifaceted energy management program affecting many systems in a building but where no base year data are available. Post-retrofit period energy use is measured by the gas and electric utility meters. Base year energy use is determined by simulation using a model calibrated by the post-retrofit period utility data.

Preliminary Measurement & Verification Plan

The table below summarizes the preliminary M&V plan recommended by Ameresco.

Preliminary M&V Plan	
ECM1:	**Lighting**
Work Description:	Option A: Pre and post measurements of a sample of lighting fixtures must be obtained. Burn hours will be stipulated in the contract, and the basis for the assumption will be documented. Savings will be reported by taking the actual measured wattages and the stipulated burn hours. Lighting savings come from all buildings.
ECM 2:	**Lighting Controls**
Work Description:	Option S: Due to the relative size of the savings of this ECM, Option N was selected. The savings will be stipulated in the contract, and no M&V will be performed, other than verification of installation
ECM 3:	**Envelope**
Work Description:	Option S: The costs associated with M&V for building envelope will exceed the expected savings. Due to the relative size of the savings from this ECM, and the small amount of savings per building, Option N was selected. The savings will be stipulated in the contract, and no M&V will be performed, other than verification of installation.
ECM 4:	**VAV Retrofit**
Work Description:	Option A: At the Recreation center and Lincoln Park Annex, the electric savings will be measured. All fans will be measured with a true RMS meter to determine demand for the baseline period. Operating hours will be stipulated. Savings will be measured by utilizing a true RMS meter to capture motor loads under a variety of speeds. The BAS will be utilized to track the speed on the fan under a variety of conditions. Savings will be calculated by ensuring the fan speeds are maintained according to the operating parameters.
ECM 5:	**Boiler Replacement**
Work Description:	Option A: Measure the combustion efficiency at one time of the baseline boiler. The hours of operation and the typical load is assumed. After the project, the efficiency of the new boiler is measured. The savings are calculated using the assumed values combined with the measured values. The one time measurement can be used throughout the performance period.
ECM 6:	**Premium Efficiency Motors**
Work Description:	Option S: Due to the relative size of the savings of this ECM, Option N was selected. The savings will be stipulated in the contract, and no M&V will be performed, other than verification of installation

Preliminary M&V Plan	
ECM 7:	**Retrocomissioning**
Work Description:	Option A: Ameresco will ensure that all operating schedules, setpoints, and other relevant parameters are properly configured to achieve the savings set forth in the energy calculations. Setpoints, schedules, and operating sequences will be checked to be working properly after the performance period.
ECM 8:	**Demand Controlled Ventilation**
Work Description:	Option A: Ameresco will configure the BAS to operate the outside air dampers to bring in less outside air based on CO2 levels in the space. The damper positions and CO2 levels will be trended by the BAS. M&V will involve verification that the dampers are operating according to the sequences and setpoints.
ECM 9:	**Pool Pump VFDs**
Work Description:	Option B: Measurements will be taken of fan demand for both pre-retrofit and post-retrofit. The actual operating hours and expected reduction in flow rates will be stipulated in the contract. Option B will be used to measure VFD speeds over time.
ECM 10:	**Out of Scope**
Work Description:	N/A
ECM 11:	**Variable Flow Pumping**
Work Description:	Option S: Due to the relative size of the savings of this ECM, Option N was selected. The savings will be stipulated in the contract, and no M&V will be performed, other than verification of installation
ECM 12:	**Out of Scope**
Work Description:	N/A
ECM 13:	**Solar PV**
Work Description:	Option S: Due to the relative size of the savings of this ECM against the total savings, Option N was selected. The savings will be stipulated in the contract, and no M&V will be performed, other than verification of installation.
ECM 14:	**Out of Scope**
Work Description:	N/A
ECM 15:	**High Efficiency Transformers**
Work Description:	Option A: Measurements of the pre and post primary and secondary loads on the transformer will be made in order to measure efficiency gains.

These M&V options are flexible and reflect the considerations previously mentioned. All specific protocols in the plans will be reviewed with the City, and finalized by mutual agreement between The City and Ameresco before construction on the project begins.