CONSULTANT REPORT

APPENDICES TO

IMPACT EVALUATION REPORT FOR ENERGY EFFICIENCY AND CONSERVATION BLOCK GRANT PROGRAM

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APPENDICES

APPENDIX A:
Detailed Evaluation Methodology

This appendix discusses the data collection and analysis methods observed during the evaluation. The methods were developed in alignment with the procedures set forth in the evaluation plan.

Data Collection Methods

This section discusses the evaluation team's approach to collecting site-specific evaluation data. Data collection fell into roughly five steps: data requests, site scheduling, site planning, site-specific measurement and verification (M&V) activities, and participant telephone surveys. Detailed data collection procedures are provided in Appendix B.

Data Requests

In June 2011, the evaluation team requested documentation from the California Energy Commission to EECBG projects. This initial data request included detailed measure descriptions, savings calculation spreadsheets and related documentation, feasibility studies (as appropriate), and contractor, vendor and equipment manufacturer information (where available). In addition, further requests were made before the scheduling of and planning for on-site activities to ensure the evaluation team had the most up-to-date project information.

DNV KEMA worked with the Energy Commission to collect consistent data organized into a spreadsheet tracking database.

Site Scheduling

For each sampled project, an evaluation engineer contacted the site via e-mail or telephone to initiate site planning and to schedule the site visit. The evaluation engineer confirmed project details and requested additional documentation, as necessary, to fill gaps not available from the Energy Commission, the site contact, and/or the project files. For example, for a typical lighting project, evaluation engineers requested a comprehensive list of installed lights, specifying fixture types and quantities, locations, and wattages of pre-existing and new fixtures. The evaluation team then notified the Energy Commission of upcoming site visits, and obtained approval for the associated travel expenses.

Site Planning

The evaluation engineers developed customized data collection and analysis plans for each sampled project. Different options for M&V were included in some of the plans since not all of the needed project information was known prior to going on-site. Site plans typically included brief descriptions of the data requirements and analysis approaches that would be used to determine both the pre and postinstallation assumptions and conditions. Site plans also indicated specific M&V activities that could be conducted when site-specific constraints were known in advance—for example, evaluators could only take spot measurements at jail projects since long-term metering was disallowed by site contacts. . Where possible, baseline conditions were evaluated with preinstallation site visits or monitoring. Sites were selected early in the

evaluation for preinstallation monitoring specifically for heating, ventilating and air conditioning (HVAC) measures. These sites were chosen based on whether it was possible to collect useful data, either from an existing energy management system or from conducting an additional site visit and installing monitoring equipment. Since HVAC system operation is seasonally driven, sites were selected based on the type of equipment and the timing of the evaluation.

Site-Specific M&V Activities

The evaluation team collected data to catalog pre and postretrofit operations and conditions. At each site visit, an evaluation engineer verified the installation and proper operation of each energy efficiency measure (EEM). The engineer also collected equipment nameplate data, feasibility study reviews, and self-reported operational data as the minimum data for all measures per site in the sample. The engineer interviewed site personnel to determine the pre and postretrofit operations, including operating conditions, load, operating hours, and control strategies. In addition to physically observing an installed measure, the engineer collected relevant data available from the site's contact, including any additional feasibility studies or updates, self-reported data from facility personnel, contractor or vendor information, cut sheets and performance curves, billing data, operational records, and research studies.

The evaluation team also requested copies of collected site data that presented pre and post conditions, including logged equipment operating schedules, major equipment power and energy consumption or sensor records, and energy management system (EMS) trend data.

End-use metering data were collected to represent the pre and postretrofit conditions when appropriate. The engineer took spot measurements, where feasible, to collect manufacturer's performance curves that would predict performance over the operation load profile and operating conditions. As needed, data loggers were installed and long-term measurements were collected over a two-week or more period. Long-term monitoring was performed at all sites except for prison sites where it was not allowed.

Sampling was necessary for sites with multiple measures or a large number of installed measures. The evaluation engineer observed the pre-existing equipment whenever possible and collected metered electrical data and other data on pre-existing operations to establish a baseline.

Telephone Surveys

Evaluators developed a participant survey instrument, which is located in Appendix C, to address research questions that could not be answered by other evaluation channels. One purpose of the survey was to provide the basis for determining net savings attributable to the program.

Evaluators screened facility contacts to identify the most appropriate person to interview based on his or her knowledge of the EECBG and involvement with project implementation and other details. Frequently,, this person was the site contact or a staff member at the project location.

Respondents were asked questions that ranged from their overall impression of the EECBG to their opinions about compliance with various application process requirements, to the financial criteria that helped the agency decide about participating, to the program's effect on jobs. An interview concluded with questions that asked about additional projects undertaken without program funding but may have been spurred by current program participation. These responses informed the spillover analysis, if participating sites implemented energy efficient measures without incentives, grants, or loans from utility or government programs and were influenced by the EECBG. Although job creation resulting from ARRA programs will be addressed in a separate report, grant program respondents were asked about the jobs created and retained as a result of the program to provide an on-the-ground indication of the perception of job creation. The survey instrument is provided in Appendix C.

Site-Specific Analyses to Determine Energy Savings

Calculating energy savings depends on the estimated base-case energy use of a given end use before to a retrofit and the estimated energy use after to the retrofit. As defined in the International Performance Measurement and Verification Protocol[1] (IPMVP), there are two ways to estimate savings:

- Avoided energy basis. Avoided energy use quantifies savings in the reporting period relative to what energy use would have been without the EEM(s).
- Normalized savings. ". . .the reduction in energy use or cost that occurred in the reporting period, relative to what would have occurred if the facility had been equipped and operated as it was in the baseline period but under a normal set of conditions.[2] "

For this evaluation, evaluators used the normalized savings approach to estimate savings. This approach assumes a fixed set of conditions in both the pre- and postretrofit cases. Thus, the base-case conditions were established for the pre-retrofit conditions as follows:

- Pre-retrofit data were collected to establish the control scheme, operating conditions, equipment load, and equipment efficiency. In the absence of metered data, information from the feasibility study, site contact, as-built drawings, and research and engineering judgment were used to establish the base-case parameters.

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1 Efficiency Valuation Organization. International Performance Measurement and Verification Protocol, Concepts and Options for Determining Energy and Water Savings, Volume 1. EVO 10000 – 1:2010, September 2010.

2 Efficiency Valuation Organization. International Performance Measurement and Verification Protocol, Concepts and Options for Determining Energy and Water Savings, Volume 1. EVO 10000 – 1:2010, September 2010., Section 4.6.1.

- Postretrofit data were similarly collected, and base-case parameters were established.

Both pre and postretrofit data were normalized to the same operating conditions to establish savings estimates that could be directly compared.

Key Parameters and Terms

This study compares the forecasted energy savings (ex ante) with the savings calculated during the evaluation (ex post). The term ex ante refers to the savings estimates reported by the Energy Commission based on information from the loan subrecipient and its contractors. Savings estimates determined from the evaluation are referred to as ex post savings.

For each site within the sample, evaluators determined a measure's efficiency, measure life, and remaining useful life of the pre-retrofit equipment.

Effective Useful Life of the Measure

California's Database for Energy Efficient Resources (DEER) was the primary source used to determine the EUL of a given EEM. For measures not represented in the DEER, the source of the EUL was based on technical research, such as published reports.

Remaining Useful Life

For all retrofit projects, evaluators estimated the number of years a piece of pre-retrofit equipment would have continued operating without the retrofit. Typically, evaluators contacted knowledgeable facility contacts and asked for their best estimate of the remaining useful life (RUL) of the pre-retrofit equipment. This self-reported RUL, when available, is thought to provide a better estimate than the evaluation estimate. Evaluators also reviewed measure life data in the DEER to assess the reasonableness of an interviewee's estimated RUL. However, DEER RUL values typically did not exist for commercial or industrial systems. Equipment older than the measure life would be expected to have no additional RUL. However, based on the status of the equipment observed during the course of the evaluation, state facilities often retain equipment beyond the EUL. For this evaluation, the site contact-reported RUL was the preferred value, DEER EULs were the second preferred value, and in the absence of both a minimum of one year RUL was used when equipment was reported as functioning at the time of the retrofit.

Equipment Efficiency

Equipment efficiency data for postretrofit operations were available from the vendor for newly purchased equipment. For older, pre-retrofit equipment, evaluators collected nameplate information during a site visit or from the project files and feasibility studies, in cases when the units' efficiencies were properly documented. In the absence of site-specific data, efficiency was based on a pre-retrofit unit's age and corresponding (past) Title 24 standards. Information on equipment efficiency, based on nameplate information, is available for many units. For example, evaluators used Preston's Guide to determine efficiencies for HVAC equipment. This

guide has a list of air-conditioning units built from 1960 through 2005 and has efficiency ratings based on a model's number and manufacture year.

Life-cycle Savings Calculations

The evaluation team calculated life-cycle savings over the lifetime of the energy efficiency measures. Each measure was assigned an EUL, and the savings for each year of EUL were summed over the measure life to determine the life-cycle savings.

Energy savings calculated for this program are relative to two established baselines, referred to as Baseline 1 and Baseline 2.

- Baseline 1 corresponds to the existing conditions found prior to the energy efficiency measure'simplementation and considers the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes that the pre-existing equipment would have operated for the full EUL of the new equipment regardless if the existing equipment was at the end of its useful life. The Energy Commission requested using this baseline to assist ARRA subrecipients that are comparing their observed pre and postretrofit energy use and are using the savings to pay back loans.
- Baseline 2 uses the pre-existing equipment as the measure baseline only until the end of the existing equipment's RUL. After that, an expected replacement baseline (for example, standard practice, or code minimum) is used until the EUL is reached.

Gross Energy Savings Calculations

The gross site savings were calculated using the difference between energy usage for the measure-treated usage and the appropriate baseline. The savings associated with most energy efficiency measureswere calculated using a spreadsheet analysis. In a few cases, calibrated end-use simulation or building energy simulation models were used to estimate savings.

Spreadsheet Analysis

For lighting controls and interior lighting projects, the evaluation team's engineers determined savings by developing spreadsheets populated with the values gathered from site visits for each fixture type's wattage, counts by fixture type, and operating hours for both existing and pre-retrofit cases. Lighting logger data, which were deployed on representative circuits at the sites, were used to establish operating hours where possible. Typically, the lighting loggers were installed at representative locations containing several occupancy and usage types (offices, hallways, garages) to establish annual operating hours for those types of locations. For exterior and streetlighting projects, the operating hours were established by the hours of darkness, determined from meteorological data for that city.

For most HVAC projects, evaluation engineers developed an annual load regression analysis that applied pre-existing and newly installed equipment efficiencies and conditions. The data collected on the pre-and postretrofit conditions were used to develop the regression analysis to establish the pre and postretrofit energy consumption. To analyze the data, evaluators

developed a regression curve relating the outdoor air temperature data to power draw for each unit. Either weather data collected on-site or local weather station data was used as a basis for establishing weather conditions that affected HVAC use. If the data indicated that loads were internally driven (for example, the power drawn by the HVAC did not correlate with temperature), evaluators developed a relationship between time-of-day and power draw. Using the installed unit's efficiency (or an efficiency curve if available), evaluators translated the power draw data into load data. Finally, evaluators converted load data back into a pre-retrofit system power-draw estimate using the efficiency, operating parameters, and condition of the pre-retrofit system. In a few cases, end-use metered data were available for the pre-retrofit condition and were used to estimate pre-retrofit system power draw. Annual savings were assessed with a bin analysis using typical meteorological year (TMY3) data (assuming weather dependency) that corresponded to a local weather station. When multiple units were replaced or retrofitted, savings were extrapolated to the remaining units at the facility.

Calibrated End-Use Simulation Models

If the ex ante savings were estimated via a building energy simulation model, evaluators made a data request to obtain these models, and in a few cases, such models were available. The models were inspected for general quality control, and when the models were of sufficient quality, the evaluation engineer determined the changes and manipulations that were made to the models to estimate the ex ante energy savings impacts. During a site visit, an evaluation engineer verified key assumptions and noted when on-site observations deviated from the assumptions or predictions of the model. After an on-site visit, the site engineer changed the as-built model to make it representative of actual conditions, creating an ex post as-built model. This model was run and the results were used to estimate ex post savings.

APPENDIX B:
DATA COLLECTION FIELD MEASUREMENT PROCEDURES

CHAPTER 1: Introduction

This document outlines guidelines and expectations for planning and performing site-level evaluations and developing reporting documents for projects executed under the Energy Efficiency and Conservation Block Grant (EECBG) and the Energy Conservation Assistance Act (ECAA-ARRA) programs. This guideline supplies general measure approaches, including data collection, field measurement, and analysis, for nearly all of the EECBG and ECAA-ARRA program project types. Consult this guide to determine a measure's appropriate data collection, field measurement, and analysis approach; this will help maintain consistency across the team of engineers who are working on these projects. The high-level measure approaches discussed in this guide indicate each measure's expected level of rigor consistent with the evaluation plans.

This document is designed for experienced energy efficiency engineers who can perform calculations for commercial energy efficiency measures. It is not intended to be a primer on how to calculate savings. Rather it serves as a companion to the evaluation plans, Final Evaluation Plan for Energy Efficiency Financing Program (ECAA-ARRA), dated June 9, 2011, and Final Evaluation Plan for Energy Efficiency and Conservation Block Grants, dated August 15, 2011. All team members are required to read and thoroughly understand the evaluation plan for the project on which they are working. This document provides additional guidance for evaluating specific measures.

Site Plans

Evaluators need to generate a clear, concise site plan prior to each site visit. Deliver this site plan with a travel request to DNV KEMA's task lead, Julia Vetromile, no later than the preceding Tuesday for the week of the proposed site visit. The site plan, which should not exceed 500 words, should briefly describe the on-site approach that will be used for each project measure. Evaluators should also discuss any proposed metering as well as the analysis type that the evaluator will use during the site visit. Sample evaluation plans are provided in Attachment C to illustrate the level of detail and clarity evaluators should capture in their evaluation plan drafts.

Safety

Evaluators who visit project sites must have completed safety training relevant to each site. At a minimum, evaluators must complete, or be able to document completion of driving safety, slips and falls, and ladder safety trainings. To conduct metering activities, electrical safety training is mandatory, as described in Attachment A. Evaluators must bring and use personal protective equipment (PPE) as applicable for each task where required or necessary. At a minimum, evaluators must bring work gloves, closed-toed work shoes, and earplugs to each site. In addition, evaluators who go on-site must follow the visited facility's safety requirements, including lockout and tagout requirements.

CHAPTER 2:
Measure Approaches for On-site Activities and Analysis

This section details general measure approaches for the most prevalent measure types in the EECBG and ECAA-ARRA programs.

General Considerations

Site visits should require no more than eight hours on-site. For sites with multiple measures or a large number of installed fixtures, sampling will be necessary. Sampling is discussed in more detail in Attachment B.

The Energy Commission developed and approved program--specific survey instruments have been developed and approved by the Energy Commission for EECBG and for ECAA-ARRA Programs. The evaluator must deliver the survey to the person identified as the decision maker for the EEMs installed. Fully completed, legible copies of all surveys must be provided to DNV KEMA.

Streetlighting & Traffic Signals

Streetlighting and traffic signal projects are strictly verification. The protocol for evaluating lighting projects is as follows:

- Obtain a comprehensive list of the installed lights for the project from the site contact or California Energy Commission's project manager. The list should specify fixture type and location for each newly installed fixture.
- Obtain specifications for the newly installed light-emitting diode (LED) or induction lights as well as the pre-existing lights. During the site visit, inspect a few pre-existing lights that have been removed from the lighting poles (if possible); this activity will allow verification of the baseline used in the ex ante analysis.
- Select a random sample of lighting fixtures throughout the city to verify in a single day. Given a day's time frame, it may be reasonable to select a sample of only a few hundred lights, even if thousands were installed. Pick fixtures dispersed throughout the city when selecting lights to verify; do not focus too heavily on any one area. Select a range of fixture wattages and types.
- When verifying lights, take pictures of a few fixtures. Bring a pair of binoculars to confirm lighting types if reviewing at a distance.
- Either photocells or timers typically control streetlighting fixtures. Site contacts should be able to provide lighting schedules if timers are in use. Obtain operating schedule data from an appropriate site contact. If photocells are in use, assume an average of 12 hours of operation per day unless there is a sound basis for a different estimate.

- Calculate savings using operating hours, fixture counts, and the difference between the pre-existing and installed fixture wattages.

Exterior Lighting

Exterior lighting projects should follow the same protocol as used with streetlighting projects, with one exception. Evaluators should verify all fixtures for exterior lighting projects, unless the fixture quantities are too high to be counted on a one-day site visit. Similar to streetlights, outdoor lights typically operate either on a fixed schedule, which can be obtained from a site contact, or on photo sensor controls. In both cases, there is insufficient schedule variability to necessitate data logging. As with streetlighting projects, it may be beneficial for the evaluator to bring a pair of binoculars to the site to verify information for hard-to-reach fixtures.

For large projects, select a sample of fixtures to verify, such that the site visit can be completed in one day. See Attachment B for additional guidance on sampling. Include a range of fixture types and wattages. Where fixtures have been installed in multiple locations, select representative areas for verification of measure installation.

Interior Lighting and Lighting Controls

Lighting measures include a wide range of energy efficient controls, fixtures, and lamps, including linear fluorescents, LEDs, exit signs, compact fluorescents, and high bay lighting,

Calculating direct savings from lighting measures are dependent on all of the following variables:

- Baseline and installed fixture wattages
- Baseline and installed fixture counts
- Baseline and installed fixture operating hours

In retrofit projects, fixture wattages and counts typically change. In controls projects—which involve occupancy sensors, da lighting sensors and/or timer controls—operating hours are generally affected. For projects where both controls and new fixtures are installed, fixture wattages, counts, and hours of operation all become important. In all cases, the wattage, counts, and hours of operation for baseline and installed fixtures must be collected.

Determine savings by establishing values for each fixture type's wattage, counts by fixture type, and operating hours for both the installed and base cases for both lighting controls and interior lighting projects. For this evaluation, evaluators will verify the installation of all new fixtures for smaller projects, and a sample of fixtures for larger projects. If a given project involves more than 500 fixtures, or if the fixtures are distributed throughout multiple small rooms or many buildings, evaluators should sample fixtures. For those cases, sample fixtures so that all affected fixture types and a variety of space types (offices, halls, lobbies, restrooms, and so on) are

represented. In the event that observed fixture counts or types vary markedly from those claimed in the application, evaluators should survey additional fixtures of the errant type.

After verifying fixture counts, evaluators should discuss the operating schedules of all affected lights with the site contact. For retrofit projects where the operating schedule is well-defined, metering is not necessary. Where the operating schedule is poorly defined, subject the fixture groups with the greatest expected usage variability to short-term (three to four weeks) time-of-use data logging to determine actual hours of operation; photocell based on/off loggers should be used for this task. For controls projects, the usage reductions attributable to the executed projects can be estimated or measured with time-of-use logging. Use appropriate references to estimate the fraction of annual lighting energy saved by lighting controls. [3] [4] In all cases, evaluators should ask site contacts for energy management system (EMS) trend data. If these data are available, it may be unnecessary to perform additional metered data collection.

Estimate values for fixture wattages by examining the power rating and ballast nameplate of the installed lamp. Again, evaluators should sample fixtures within reason, since accessing and opening fixtures to examine the ballasts adds considerable time to an audit. In most cases, examining three to five fixtures should suffice for evaluation purposes, since most projects typically use only a few types of ballast.

Evaluators should discuss the measure baseline specified in the project documentation with the site contact to verify that the fixture counts and types used in the ex ante analysis are appropriate for the ex post analysis. If not, request documentation specifying the actual pre-existing equipment (for example, an internally performed lighting inventory or a building lighting plan).

Following the retrieval of data loggers, evaluators should calculate savings for lighting projects using a spreadsheet analysis. Operating schedules (developed from logger data), fixture counts, and the difference between the pre-existing and installed fixture wattages serve as the basis for savings calculations.

Vending Machine Misers

Direct savings calculations for vending machine misers are based on unit operating hours, number of units, energy load per unit, and number of occupants. Vending machine misers have occupancy sensors that detect users in the vicinity. If no occupant is detected, the vending machine will conserve energy by shutting off the compressor and lighting fixtures until a user is detected by the occupancy sensor. Typically, the more occupants there are in the building, the less downtime the vending machine will have and the less energy saved. However, if the

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3 Northeast Energy Efficiency Partnership. 2010. Mid-Atlantic Technical Reference Manual, Version 1.0, page 83ff.

4 Business Programs Deemed Savings Manual V1.0, State of Wisconsin (pages 4-192ff).

vending machine is in a location with minimal foot traffic, then the vending machine misers can save a considerable amount of energy. Vending machine misers also have a built-in temperature sensor that will turn on the compressor to maintain a proper internal temperature for cold food and beverages. A large part of the energy savings results from the reduced number of compressor cycles per day.

Upon assessing vending machine misers, evaluators should verify that the occupancy sesnsor on the vending machine is installed and operating properly. This may include testing the effectiveness of the occupancy sensor by determining if the machine truly powers off when no user is detected. Generally, the on-mode power usage is not decreased, but the on-mode time-of-use will decrease with the use of vending machine misers. Two options are available for determining savings.

- The evaluator can collect and record a spot power measurement. The evaluator then used the measured power value and assumed the unit ran for all hours throughout the year in the pre retrofit case. Vending machine controls were assumed to reduce annual consumption by 46 percent in the post retrofit case. This value is claimed by the manufacturer and supported by various independent case studies. This value is also used in multiple technical resource manuals to estimate vending machine control savings.
- The evaluator can estimate the operating hours and load profiles of the misers by accounting for the number of occupants, the type of building, and the location of the vending machine. Several studies have documented typical energy use and percentage savings from both refrigerated and nonrefrigerated vending machines misers based on these factors.[5] A site contact can typically provide estimates for occupancy and foot traffic. Evaluators can calculate the energy savings resulting from the installation of vending machine misers from the difference between baseline and installed operating hours as well as the operational energy loads.

Industrial Motors and Pumps

Generally, projects industrial motors and pump projects entailed switching from less efficient motors and/or pumps to premium-efficiency motors and/or high-efficiency pumps, or installing variable frequency drives. For pumps and motors, two factors dictated savings: the differing efficiencies between the installed and base case equipment and the load profile of the equipment. For variable speed drives, evaluators collected information from the site about the power draw of the motor, and the load profile. During site visits, evaluators verified the equipment specifications for the newly installed and removed pumps and/or motors and

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5 Massachusetts TRM: (pages 211-213) http://www.ma-eeac.org/docs/MA%20TRM_2011%20PLAN%20VERSION.PDF, *Business Programs Deemed Savings Manual V1.0*, State of Wisconsin (pages 4-81 to 4-83).

confirmed pre- and postinstallation operating hours with the site contacts, and determined the load profile of the equipment using spreadsheet analysis. For sites where it was available, billing and supervisory control and data acquisition (SCADA) data were used to develop annual usage profiles for the new pumps and motors and determine savings.

Personal Computer Power Management

Personal computer (PC) power management measures involve installation of control software on computers in order to manage computer power settings from a centralized location. The software puts the PCs into a reduced power state without interfering with end-user productivity, desktop maintenance or software upgrades. The PC power management software is installed at the server and subsequently distributed to each identified PC via the server.

Upon assessing a PC power management measure, evaluators should verify that the software is installed and operating properly on each PC. A general savings algorithm takes into account the number of computers, power requirements of the computers at various operation modes (on, off, suspend), and changes in hours of operation at each mode due to the power management software are used to determine savings. Hours of operation at these different modes are based on established studies for office equipment while the power draws at the various operating modes are based upon ENERGY STAR®-compiled data regarding computers. Using these two sources, DNV KEMA calculated the annual electrical energy savings for each desktop computer controlled by PC power management software. For the postretrofit case, the power draws for each mode were unchanged, but the operating hours at each mode shifted to reflect the power management software settings. Using this analysis, total energy savings for this measure were calculated.

Packaged HVAC Equipment

Generally, evaluators determine savings from packaged heating, ventilation, and air-conditioning (HVAC) retrofit projects using one of four approaches. These approaches are defined in the HVAC Evaluation flow sheets.

Four cases are defined, depending on whether pre-retrofit monitoring is performed (Cases 1A and 1B) or only postretrofit monitoring is performed (Cases 2A and 2B). For projects where a major portion of the HVAC units at a facility are replaced, use the more rigorous approach of Case 1A or 2A. For Case 1A and 2A, use one either a building hourly simulation model approved by the Energy Commission (eQuest or EnergyPro), or a bin model engineering analysis to estimate energy savings. For Case 1B and 2B, use a bin model calculation. The modeled data was calibrated using the best available data. Data specific to the units replaced or modified was preferred; such as with direct metering of equipment or energy management system data. Utility bills were collected when possible. In cases where the split of the utility bill into end-uses could reasonably be performed, the evaluator can calibrate with the utility bill. The utility bills were also assessed to determine the reasonableness of the savings estimation..

The following procedure provides evaluators with general guidelines for analyzing packaged HVAC projects. Steps one through six apply to all potential analysis options; the remaining steps present analysis strategies specific to each analysis approach.

1. Ask the site contact for access to each of the newly installed units. Verify that each unit has been installed as claimed. Record the model information for each newly installed unit in accordance with the fields provided on the site form.
2. Depending on the number of newly installed units for a project, evaluators may meter either a sample of the units or all of the units. As a general rule, evaluators should pick a representative sample if there are more than three units. The sample should represent both the sizes of units monitored as well as the space types served by the sampled units. Evaluators should not install more than four true power loggers at any one site. Meter a sample or all units using a Micro Station/WattNode logger/transducer combination, according to the protocol outline for HVAC packaged units in Attachment A. Also, take spot measurements to ensure the validity of the metered data. Attachment A includes discussion of the proper protocol for spot measurements. When metering is not possible or practical, note the conditions why metering could not be reasonably performed.
3. In addition to installing power loggers, evaluators should install a weather station logger on a site roof to record temperature and relative humidity data for the duration of the monitoring period. The weather station should be located in the shade whenever possible. Synchronize the weather station's logging interval with the power logger's logging interval to make data postprocessing easier.
4. Discuss unit(s) schedules and operations with the site contact. Answer scheduling questions provided on the site form, as applicable. These data provide context for interpreting the metered data.
5. Gather any available data on a site's pre-existing units, especially nameplate data which can be used to determine efficiency at time of purchase. Request information on the control system, how the system typically operated, the age of the equipment and operational maintenance issues. Ask about recent repairs or problems, indicating whether the equipment performance may have degraded over time (for example, thermostat problems, control overrides, refrigerant leakage, duct repairs, or leaks). At a minimum, evaluators shall collect the pre-existing units' sizes and vintage of the equipment. The site contact may have building plans, as built drawings, or product manuals that will facilitate defining accurate base cases.
6. Remove the kWh data loggers and the weather station on the back-end site visit, which should occur roughly four weeks following the initial site visit. Review the weather station data; compare it to available regional weather station data to confirm validity. Attachment A discusses protocols for properly removing the power loggers.
7. Where a simulation modeling has been developed by the implementer, collect building information that affects the HVAC to verify a sample of the model inputs, including:

- Schedules and Building shell characteristics. including dimensions and orientation (for hourly simulation)

- Wall R-values, roof R-values, roof color (for hourly simulation); where R-value is a measure of thermal resistance of a material assembly.
- Window types, dimensions, orientations, U-values, and solar heat gain coefficients (if available) (for hourly simulation); where U-value is a measure of non-solar heat loss or gain through a material assembly.
- Plugs loads (computers, monitors, copy machines, refrigerators, coffee machines, and so forth) and plug load schedules
- Lighting loads (LPD) and lighting schedules
- Process loads and schedules
- HVAC system heating and cooling set points and scheduling
- Nameplate information of HVAC equipment
- Fan operating strategies (constant, cycling, nighttime set back, and so forth)

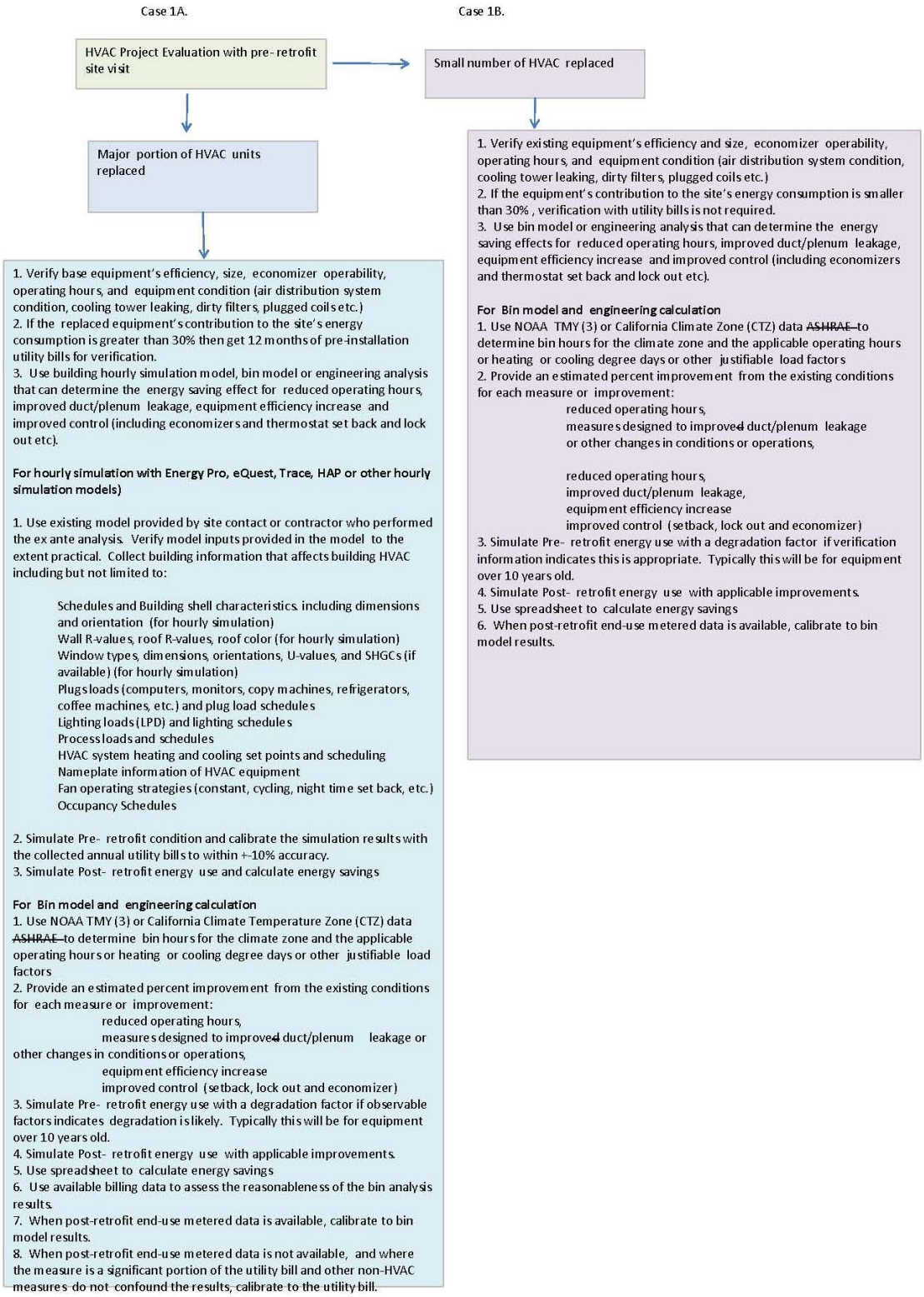
Use this information to verify the pre-existing building model.

- Where a spreadsheet analysis is planned, create a spreadsheet to develop the load profiles for both pre and postretrofit conditions. Evaluators should use the metered data to develop a regression curve relating the outdoor air temperature data to power draw for each unit. If the data indicate that loads are internally driven (for example, the power data does not correlate with temperature), develop a relationship between time-of-day and power. Using the efficiency of the installed unit (or an efficiency curve if available), translate the power draw data into load data. Where pre-retrofit metered data is available, calculate energy savings by developing and then comparing the pre-existing and newly installed units' regression curves. Where pre-retrofit data is not available, convert the load data back into an estimate of base case system power draw using the efficiency of the baseline system. Employ a degradation factor to the efficiency if warranted by the site observations and information collected. Annual savings can be assessed with a bin analysis using TMY3 data (assuming weather dependency) that corresponds to a local weather station. After determining savings within the sample of metered units extrapolate savings projections to the remaining units at the facility.

- When using an existing simulation model of the building, verify that the installed equipment, operating and control strategy, and a sample of model inputs are correct based on the site observations. The HVAC end use of the model is then calibrated to metered data by adjusting loads and other parameters in the model to bring the observed and modeled demand profiles into agreement. Two more versions of the model are then created: one with existing equipment and the other with Title-24 baseline equipment. Each of the models is then run with the appropriate TMY3 weather file and savings are calculated based on the differential between the installed and base case models (for example, the existing model according to the existing conditions [Baseline 1) and the Title 24 model for the dual baseline [Baseline 2) calculation.

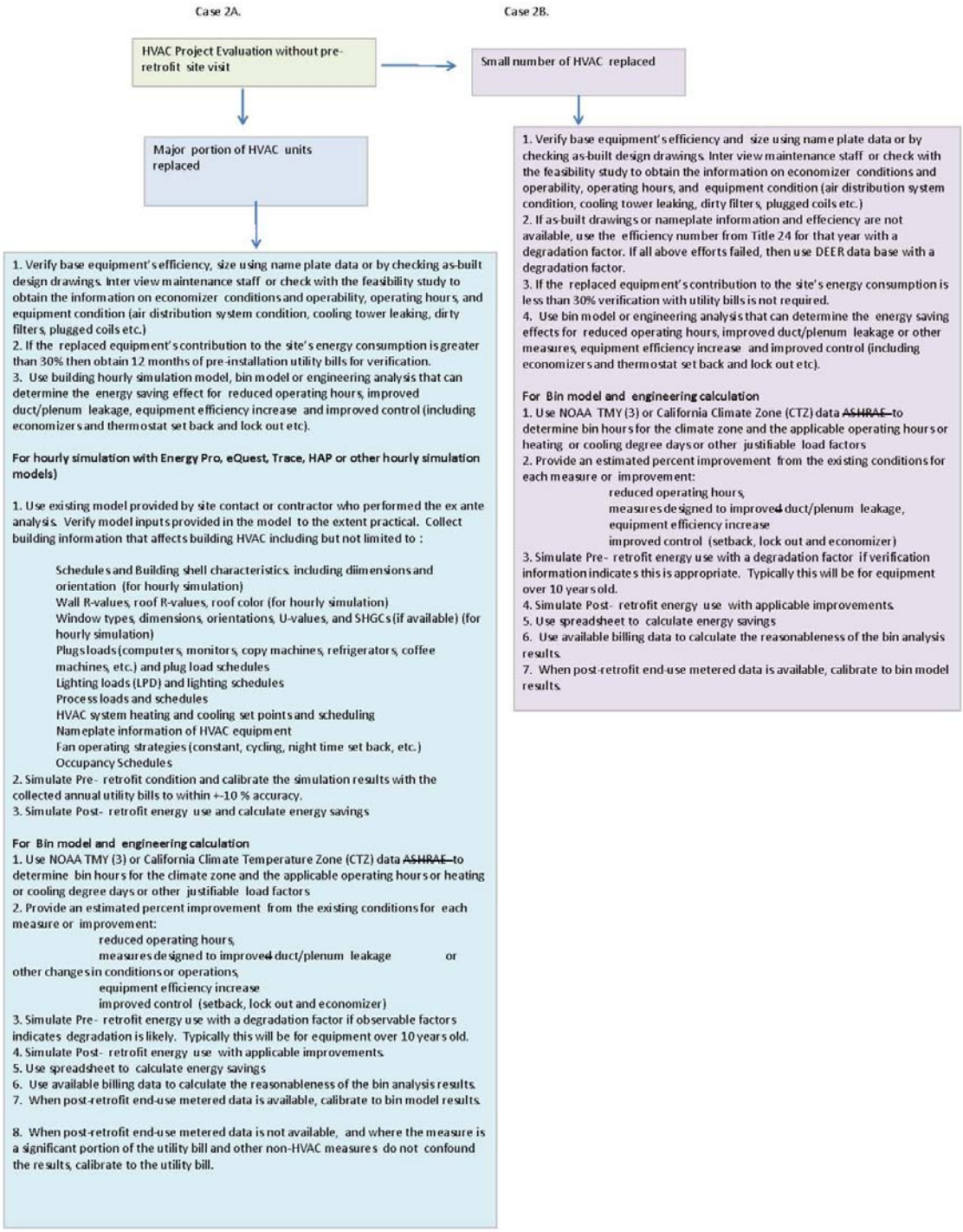
In some cases, it may not be possible or practical to collect useful metered data. Air-conditioning projects that must be evaluated prior to the hot season are one example. As described on the Evaluation Flow Sheet, ,engineering spreadsheet models using bin weather data will be performed are These models are more theoretical and generally rely on spot measured parameters and assumptions made using engineering judgment. This approach will typically be used in cases where a small size or a small number of HVAC units are replaced.

Figure 1. Evaluation Flow Sheet – Case 1A and Case 1B



Source: DNV KEMA analysis

Figure 2: Evaluation Flow Sheet – Case 2A and Case 2B



Source: DNV KEMA analysis

Built-Up HVAC Measures: Central Plant

Central plant HVAC measures include boiler retrofits, chiller retrofits, pump retrofits, and VFD installations, as well as many other possibilities. Use the Evaluation Flow Sheets (Figure 1 and 2) as a guide for the evaluation approach, as described in the preceding section (Packaged HVAC Equipment).

Evaluators must establish a load profile for newly installed central plant HVAC measures (pumps, cooling tower fans, chiller compressors, and so on). For most chilled-water projects, establishing a load profile for the loan or grant financed equipment requires determining a load profile for the chiller, regardless of whether the measure directly affects the chiller. Once the evaluator correlates the chiller's power draw to its corresponding outdoor conditions (or time of day for process chillers), most other parameters required to calculate the savings can reasonably be determined. For instance, consider a project that retrofits constant-speed chilled-water pumps, condenser water pumps, and cooling tower fans with VFDs. Once determined or estimated, the load of the chiller can be used to project the required chilled and condenser water flow rates using the temperature drop (delta-T) across each chilled-water loop. Likewise, determining a the load of the chiller will allow evaluators to calculate the fan speed requirement, if evaluators know the outdoor wet-bulb temperature and theperformance of the tower under design conditions. In both scenarios, knowing the chiller's load profile effectively establishes the load profile for the equipment of interest. Establishing the chiller's load profile, via either kW metering or EMS data acquisition, is vital to determining savings for many plant HVAC measures.

The analysis approach for central plant HVAC measures is as follows:

- Verify installation of a plant's new HVAC measure equipment. Record nameplate data.
- Determine if an EMS system is available and collects true power data on the equipment of interest. If so, evaluators may not need to use outside monitoring equipment. Evaluators should also inquire about the availability of other EMS trend parameters of interest. Some commonly recorded plant parameters include pump and tower fan VFD hertz (Hz), pump and tower fan operating hours, chilled water entering and leaving temperatures, and condenser water entering and leaving temperatures. If EMS system data is not available, install data loggers on the project's equipment of interest. Evaluators will want to install true power data loggers on the chiller(s), as well as any measure-specific equipment.
- Confirm the validity of the metered data with spot measurements. Install a weather station on the site's building roof to record ambient temperature and relative humidity weather data. Synchronize the logging times for the loggers and weather station to ensure that all data *line up* during the analysis phase, if possible.
- Discuss plant operations (for example, schedules, set points, and equipment configurations) with a site contact or building engineer. Determine control strategies for

the project's equipment of interest and gain an understanding of the loads served by the plant's equipment. For instance, does the chiller maintain a constant delta temperature across the evaporator, or does the delta temperature T shift under low load conditions? Does the plant use water-side economizing? Is the condenser water temperature set-point fixed, or is it allowed to float? Depending on a project's measures, any and all of these questions might be important.

- Discuss the pre-existing equipment and the installed equipment with the project site's building engineer. Gather any available data on the pre-existing equipment, especially nameplate data that can be used to determine efficiency at time of purchase. If possible, review as-built building plans, which may include a mechanical schedule listing the pre-existing equipment. Ask the building engineer how the plant previously operated with the old equipment in place, including the control strategies. Request information on the age of the equipment and operational maintenance issues. Ask about recent repairs or problems, indicating whether the equipment performance may have degraded over time (for example, thermostat problems, control overrides, refrigerant leakage, and so forth).
- Return to the facility and remove the logging equipment after a three- to four-week monitoring period.
- Develop a regression relationship between chiller power and outdoor conditions using the metered data collected from a site. Using the chiller's part-load efficiency curve, translate this curve into a load (tons of refrigeration) versus an outdoor-conditions relationship. Relate the chiller load data to the remaining plant equipment using the operating data, gathered from the site's building engineer, and metered data from the plant's other equipment. Conduct a bin analysis using typical meteorological year data from a nearby weather station to quantify the measure's effects.[6]

The following example analysis shows a project's possible execution.

A facility receives a loan or grant for installing VFDs on its primary loop chilled- and condenser water-pumps, which were previously controlled using manually throttle valves. While at the facility, the evaluator obtains the site EMS power data for the chiller and installs true power loggers on the project's pumps of interest and a weather station on the roof. Back in the office, the evaluator uses the chiller power data, weather data, and a chiller efficiency curve to estimate chiller load as a function of outdoor conditions. Using this load curve, and knowledge of the fixed water loop Delta-T set points, the evaluator estimates the chilled- and condenser-water

6 For a given city, TMY3 weather data approximates the average 8,760 weather conditions using climate data from the 1991 to 2005 period of record. TMY data sets are designed to simultaneously maintain the range of typically observed extreme weather conditions and are aggregated to the annual average weather conditions.

flow rates under various load conditions. Next, the evaluator uses the flow estimates to predict the pumps motors loads using the baseline throttling valve control strategy. Lastly, the evaluator compares energy usage under the baseline control strategy to energy usage under the VFD control strategy—obtained from monitoring—and annualizes the results using a bin analysis to determine overall project savings.

For gas-related plant measures (boilers, large domestic hot water [DHW] heaters), evaluators must use a different approach. In most instances, equipment specifications, schedule and set-point data, utility gas bills, and possibly verified combustion efficiency data, will be the only data available to the evaluator. If the project boiler(s) or DHW heater(s) of interest are the only large gas users on the project participant's utility bills, the analysis will be straightforward. Evaluators will conduct an analysis using the differing efficiencies of the base case, installed boilers, and the project facility's gas load. If possible, evaluators should adjust these efficiencies from the manufacturers' claims using combustion test results, blow-down estimates, flash-gas estimates, and shell-loss projections.

If other large gas users comprise a significant portion of the participant's gas utility bills, evaluators should use a simplified building-simulation-based analysis to assess project savings. See Attachment C for a brief discussion of building simulation modeling-based analysis for this measure type.

In some cases, it may not be possible to collect useful metered data. These projects will be determined on a case-by-case basis.

Built-Up HVAC Measures: Air Side

Air-side HVAC measures may include air handler constant volume (CV) to variable air volume (VAV) conversions, economizer retrofits and retrocomissioning, automatic thermostat installations, EMS upgrades (which may also affect plant equipment), and building set-point adjustments. For mechanical measures, evaluators should use a spreadsheet analysis, informed by metered data, when a site's air delivery system changes in some measureable way. Use the HVAC Evaluation Flow Sheets to determine the method. Evaluators may determine the impact of control measures using either spreadsheet analysis or simulation modeling. If spreadsheet models are used, savings are projected in terms of reduced equipment full load hours or bin-hours. If evaluators are provided with simulation models used as part of the ex ante analysis, they may instead decide to use and modify these models to project savings. In cases where simulation models are not provided, the opportunity cost of spending additional time on control measure simulation at the expense of rigorously analyzing other measures is generally considerable. Therefore, evaluation engineers use simulation modeling for control measures only when ex ante simulation models are provided for review and modification.

The standard approach for air side measures is as follows:

- Verify installation of the loan or grant financed equipment.

- If necessary, install data loggers to track operation of the loan or grant financed equipment(kW meter for VFD applications and temperature data loggers for economizer applications).
- Take spot measurements of the financed equipment, if necessary (supply- and return-fan-related measures only). Use these measurements to verify the validity of metered data.
- If logging data, install a weather station logger on the project site roof to track local temperature and relative humidity conditions over the monitoring interval course. Synchronize the logging interval of the weather station with the logging intervals of other metering equipment. Review the weather station data for reasonableness compared to available regional data.
- Discuss the equipment operations of the project with a participant's building engineer. Record relevant information as presented in the field forms to the interpretation of the metered data. For instance, ask a site's contact to indicate the high-limit enthalpy for economizer operation and the minimum outside air set point if a single-point enthalpy economizer is recommissioned. These data can be cross-referenced with temperature logger data to verify the economizer's correct operation.
- Discuss the pre-existing equipment with a site's contact or building engineer. Investigate the ways in which equipment operations may have changed as a result of the project (particularly important for control measures). Review an original set of as-built plans to record pre-existing system data, if possible.
- For projects involving logger installations, retrieve data loggers after three to four weeks of equipment monitoring.
- Construct a model correlating ambient weather conditions and/or time of day to equipment's operation. Estimate the baseline equipment operation from data gathered from a site contact. Determine the measure's annual savings using either a bin, EFLH or 8760 model; in either case, use TMY3 weather data from a nearby weather station for all final savings projections.

Custom Measures

Custom measures include a disparate array of project types, ranging from computer server virtualization, to mechanical aerators used in wastewater treatment. Each project type requires that evaluators use their best engineering judgments to develop a measure-specific evaluation approach. Whatever the project, evaluators should consider the following questions:

- Given the number of analysis hours allocated to a project site, which analysis approach makes the best compromise between analytical rigor and cost effectiveness?
- Is metering appropriate and practical?

- How will evaluators use metered data, together with information gleaned from a site contact's interviews, to develop an annual load/usage profile for the installed equipment?
- How can evaluators translate the load/usage profile for the installed equipment into base case usage? Have they gathered enough data on the base case equipment to confidently estimate base case usage under all operating modes?
- For industrial (primarily wastewater) measures, have evaluators asked a site contact for daily process records (for example, gallons per day of water) for the past year?

CHAPTER 3:
Reporting Requirements

Site reports should be succinct and should answer the following questions:

- Which measures were implemented?
- Were the measures installed as proposed?
- Does the baseline equipment listed for the project seem reasonable given the observed facility conditions?
- How were savings determined for each implemented measure? What were the savings for each measure?
- If savings differed drastically from ex ante projections, why?

All calculations, tabulated results, and figures showing measurements should be provided. The report will provide an explanation of the analysis performed; backup spreadsheets with the detailed calculations will become part of the project record.

The following results must be identified:

- Annual energy savings, based on the pre-existing equipment operation (Energy Commission baseline).
- Measure life.
- Remaining useful life of the existing equipment, based on the decision-maker survey, information gathered during the site visit, and engineering judgment.
- Normal replacement annual energy savings, if different from the Energy Commission baseline.
- Lifetime savings, based on the existing equipment (Baseline 1).
- Lifetime savings, based on dual baseline (Baseline 2) of early replacement for the remaining useful life of the equipment, followed by normal replacement savings for the remaining years of the measure.
- Realization rate, on a measure basis.

DNV KEMA will distribute example reports once the first few reports are accepted by the Energy Commission. At that time, DNV KEMA will also distribute a reporting template to use for all site reports to maintain consistency.

CHAPTER 4: Glossary

AHU	air unit handler
CFL	compact florescent lamp
CT	current transducer
CV	constant volume
DHW	domestic hot water
DOE	Department of Energy
Delta T	Temperature difference
ECAA	Energy Conservation Assistance Act
EECBG	Energy Efficiency and Conservation Block Grant
EEM	energy efficiency measure
EMS	energy management system
Energy Commission	California Energy Commission
EPRI	Electric Power Research Institute
HID	high Intensity discharge
HVAC	heating, ventilation, and air-conditioning
LED	light emitting diode
LPD	lighting power density
PF	power factor
PPE	personal protective equipment
RH	relative humidity
RMS	root mean square
SCADA	supervisory control and data acquisition
TYM3	typical meteorological year 3
VAV	variable air volume
VFD	variable frequency drive

Attachment A:
Metering Protocols

Many projects executed under both the ECAA-ARRA and EECBG programs will require data logging of some kind. This section discusses the data logging instrumentation that evaluators should use for these projects. Evaluators should inform a site contact about any proposed metering during their initial scheduling call for any project that will require metering. Tell the site's contact what will be installed, where it will be installed, and for how long. In this manner, equipment access or safety issues can be resolved before a site visit, and metering can occur as planned.

Installing power meters requires opening electrical panels and poses certain safety risks. All field staff working on this project must complete DNV KEMA's courses on electrical safety, driving safety, and ladder safety, or provide documentation from another program indicating that similar training has been completed in these areas.

Packaged HVAC – WattNode Metering

This section provides a specific, step-by-step metering protocol that evaluators should use for packaged HVAC equipment.

Meter Installation

After gaining access to a project's roof by a site's contact, evaluators should follow these protocols to install the metering equipment and to verify its correct operation.

- Before touching any energized equipment, remove all metallic jewelry and put on all safety gear as required by the National Fire Protection Association 70E standards.
- Identify the power connection configuration at the disconnect box. It is single phase if there are two lines leading from the fuse to the unit. If there are three power lines and a fuse, it is a 3-phase Delta configuration. If there are three power lines and a neutral line, it is a 3-phase wye configuration.
- Identify the source voltage provided to the unit by reading the nameplate. Some units installed at older facilities have ratings at 208V/3-phase, while more modern facilities typically have 480V/3-phase power supplied to the units. For 480V supplies, use the WNB-3D-480-P WattNode meter; for 208V supplies, use the WNB-3D-208-P WattNode meter.
- Turn off the power to the unit by flipping the manual power switch. If there is no local disconnect, consult a site contact and call the field manager as needed to disable power. Open the unit service panels and observe the power lines feeding it. Confirm that the system is completely off before installing any equipment. Verify this by measuring the voltage at the terminals for each leg. If the voltage is not zero, there may be some residual power left in the system from the capacitors. Wait until the unit discharges completely before performing work on the system. If necessary, use a discharge rod to

achieve zero voltage on the terminals. Never touch the capacitor leads while working in the unit; capacitors may maintain charge for extended periods of time.

- Use an insulated screwdriver to partially unscrew the connection from the first leg at the terminal block. Insert the Phase A wire from the WattNode into the unscrewed terminal leg. Retighten the screw so that both the power line feeding the unit and the Phase A wires from the WattNode are tight. Wiggle the wires to see if they become loose.
- Take the current transducer (CT) (Phase A) coming from the WattNode and slip it around the first line. Install the CT on the line side (before the fuse) of the terminal block whenever possible. If the load side (after the fuse) must be used due to lack of space, take care to capture all wires exiting the load side of the terminal block for the desired phase. When installing the CT, make sure it is installed with the correct side facing the source. Magnelab's CTs typically have a sticker indicating the face that should be pointed toward the source (see Figure 3 below). Should the source face not be indicated, compare the teeth configuration of the split core to a marked CT to determine the correct direction for installation.

Figure 3: Current Transducer

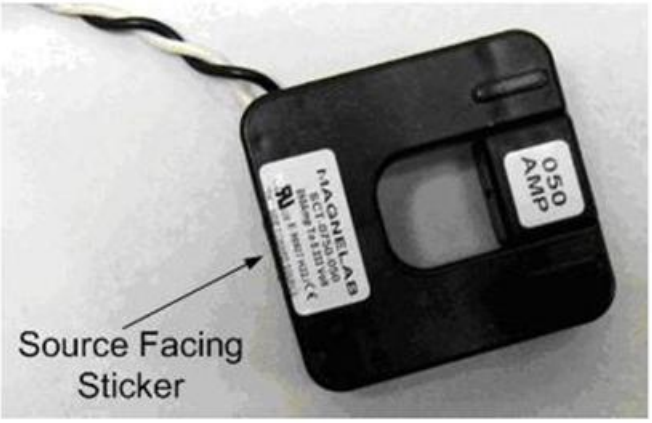


Photo Credit: DNV KEMA

- Repeat steps 4 and 5 for the second (phase B) and third lines (phase C) and make sure that the appropriate CTs are connected to the corresponding lines.

If the power configuration is *3-phase wye*, attach the neutral voltage lead from the WattNode meter to the unit's neutral connection and attach the ground voltage lead from the WattNode to the unit's ground connection. If the power configuration is single-phase or 3-phase Delta, attach only the ground voltage lead from the WattNode to the system's ground connection (and remove the pre-attached neutral wire from the WattNode). Note that 3-phase Delta units are most common.

The WattNode should be preconnected to the HOBO Micro Station using a pulse adapter cable.

- Insert the serial communication cable into the Micro Station unit and a computer. Turn on the power to the system, and let it run.
- Deploy the Micro Station. Verify that the lights on the WattNode are blinking green. If the lights are not blinking green, some combination of green, yellow, and red lights will flash. Refer to the WattNode troubleshooting guide (included in all site kits) to determine the WattNode error, and address the issue. Perform adjustments to the WattNode's set up only with the power OFF.

Figure 4: WattNode Status Indicator Lights

Photo Credit: DNV KEMA

- Once the WattNode is operating correctly and the Micro Station has been launched, perform an installation quality check by comparing the WattNode's power readings to root mean square (RMS) power readings captured using a spot power meter.

Refer to the conversion table presented in Table 1 to calculate the system's RMS power using the pulse data output from the WattNode unit.

Table 1: WattNode Pulse Output Conversion Factors

Model	Watt-hours/Pulse/CT-rated Amp
WNB-3D-240-P	0.02500
WNB-3D-480-P	0.05771

Source: http://www.ccontrolsys.com/ww/images/f/fb/Manual_WNB_Pulse.pdf

For an example to use this table, consider an application where 25A CTs are used with a WNB-3D-240-P WattNode. At a given time stamp, the Micro Station records an output of 25 pulses (over the 1-minute logging interval). The RMS power would be calculated as:

$$kW_{Wattnode} = (.025)(25A)(25\,pulse)(3600\frac{s}{hour})\left(\frac{1}{60s}\right)\left(\frac{1}{1000}\right) = .9375kW$$

See below for instructions on how to properly take spot power measurements. Since the WattNode and spot measurements will not correspond to identical time stamps, spot power readings within a range of +/- 25 percent relative to the WattNode readings are acceptable. WattNode power measurements should be taken from a time stamp beginning at least three minutes after a logger is launched and after turning back on a unit to allow for compressor operation to reach the steady state.

- If the numbers are synchronized, remove the communication cable and place the Micro Station in a secure area away from the elements and in plain view.
- Perform a final visual inspection of the equipment to ensure that the logger, WattNode, and CTs are installed correctly. Refrain from touching the equipment if any issues are identified. As always, first shut off the power to a unit before making adjustments.
- After ensuring that the logging equipment and wires are safely situated, close the service panels. Turn the unit back on and make sure it runs. If necessary, adjust the thermostat in the building to force the unit on and check for correct operation.

Meter Removal

Take the following steps during a return site visit to safely remove the metering equipment.

- Before touching any energized equipment, remove all metallic jewelry and put on all personal protective equipment.
- Turn off the power to the unit by removing the fuse at the disconnect box or flipping the manual power switch. Open the unit service panels, and observe the power lines feeding it. Make sure that the system is completely off before removing any equipment. This can be verified by measuring the voltage at the terminals for each leg. If the voltage is not zero, there may be some residual power left in the system from the capacitors. Wait until the unit discharges completely or discharge the unit using a discharge rod before performing work on the system. If necessary, use a discharge rod to achieve zero voltage on the terminals. Never touch the capacitor leads while working in the unit; capacitors may maintain charge for extended period.
- Use an insulated screwdriver to partially unscrew the connection from the first leg at the terminal block. Remove the Phase A WattNode wire from the terminal block. Re-tighten the terminal block screw so that the power line feeding the unit is securely fastened. Wiggle the power line to see if it comes loose. Repeat this process for the remaining phases and the ground connection.

- Remove the CTs from each phase.
- After removing all logging equipment from the unit, securely reinstall the panels.
- Turn the unit back on, and make sure it runs. If necessary, adjust the thermostat in the building to force the unit on and check for correct operation.

Spot Power Measurement Check

The accuracy of all meter installations must be verified using spot measurement checks with a power meter (typical full-range accuracy +/- 2 percent). While taking spot power measures, ensure that the thermostat is set sufficiently low to maintain compressor operation. Alternatively, use jumpers to override the thermostat during the test period. Spot measurements should consist of voltage, amperage, power factor, and True Power readings. Take a minimum of three sets of spot measurements one minute apart. To ensure the consistency of readings, perform spot measurements using the phase-to-neutral method described below:

- Connect the black voltage probe from the Fluke or Amprobe to a neutral/ground.
- Connect the red voltage probe to Phase A.
- Connect the amp clamp across Phase A, and verify that it is facing in the correct direction.
- Push the Phase Check button to verify the direction of the current or simply check the sign of the current. If current is negative, then the amp clamp is facing in the wrong direction.
- Record the voltage, current, power, and power factor from the Fluke liquid crystal display (LCD) display.
- Move the red voltage probe and amp clamp to PPhase B.
- Repeat steps 4 & 5.
- Move the red voltage probe and amp clamp to Phase C.
- Repeat steps 4 & 5.
- Disconnect both the voltage probes and amp clamp.

Compare the readings to the concurrent readings from the metering suite. Spot measurements should be within +/- 25 percent of the metered value. Metered and spot measured readings should not be expected to match exactly since the logged value represents the time averaged power consumption over the logging interval (60 seconds). However, if the metered values over

the course of a few time stamps are not in a close range to the spot checked values, reconfirm the meter's installation to check for these possible deficiencies:

- CTs installed in the wrong direction
- CT clamps not fully closed
- Mismatch between CT and voltage lead phases
- Improperly installed voltage leads (this is potentially dangerous and must be avoided)
- Poor connections to the WattNode from the voltage leads, current transducers, or pulse adapter

If none of the aforementioned issues are the source of the problem, use the best engineering judgment to assess the likely cause of the problem. If the problem is clear, replace the failing component. If the problem cannot be identified, switch out the entire metering suite with a backup.

True Power Metering, Current Logging, and Other Monitoring Instrumentation

Outside of packaged unit applications, perform true power logging using DENT ELITE*pro*™ meters. Unlike the WattNode-based loggers, which are hard wired into equipment and are generally suitable for only packaged applications, DENT ELITE*pro* loggers use alligator clamps to attach to exposed voltage sources (for example, terminal blocks). As such, these loggers can be installed on live equipment, which may be necessary for large commercial and industrial projects. If you need training on how to use and install DENT loggers, please contact Brandon Gill (Brandon.Gill@dnvkema.com). Be aware that ELITE*pro* loggers must be installed on the line side of VFDs since they are only capable of monitoring standard 60 Hz AC signals.

Figure 5: DENT ELITE*pro* True Power Logger

Photo Credit: DNV KEMA

For projects that only require current metering, DNV KEMA uses ACR OWL current loggers and/or Onset HOBO Micro Station data loggers fitted with a single current transducer. Both of these options employ split-core current transducers for installation ease.

Figure 6: Onset Micro Station and ACR OWL Current Logging Solutions

Photo Credit: DNV KEMA

In addition to power and current metering, DNV KEMA regularly uses indoor temperature and relative humidity data loggers, outdoor weather station data loggers (also Temp/RH), and time-of-use lighting loggers.

Attachment B: Sampling

Engineers will find it necessary to use sampling techniques both in the context of verifying equipment installations and metering equipment. As an example, it generally will not be reasonable within the limitations of a one day site visit to verify the installation of lighting in 10 different buildings for a single project. Similarly, it will not always be possible to meter every packaged unit installed as part of an HVAC retrofit project. Both of these examples require sampling that should be conducted on the basis on a few key considerations:

- For installation verifications activities (typically light measures), as many units as possible should be verified within the limits of the on-site time allotted for the site *without* detracting from any other required on-site activities. As an example from an already completed Energy Commission evaluation project, an engineer had to verify lighting, remove a logger from a chiller, discuss and verify two boiler controls measures, discuss an EMS measure, and meter a few packaged HVAC units all in one day. In this case, it was not reasonable to verify the 1,000 lights retrofitted as part of this project. Instead, a sample of lights was verified.
- If verification sampling must be performed in a limited timeframe, maximize available time by verifying those units responsible for the greatest portion of the energy savings. For instance, if lighting retrofits were performed in six buildings, but the retrofits in two of those buildings accounted for 85 percent of the savings, the engineer should make an effort to verify those two buildings before any of the others.
- **The scope of verification activities should partially be dictated by the accuracy of the verification sample.** If, while verifying lights at a given facility, an engineer determines that the lighting schedule provided by the site contact is grossly flawed, added time should be allocated during the site visit to verify more lights than initially planned—especially if the lighting portion of the project accounted for a large amount of the savings. Discretion must be used in the analysis phase when applying any savings degradation factor determined for the verified area to the unverified area. If the savings for unverified areas are reduced or increased for reasons unrelated to updated operating hour estimates, the verified sample needs to provide strong evidence that *all* areas of the project were not completed as proposed.
- **When sampling equipment for metering, attempt to cover a wide range of equipment sizes and unique usage profiles.** As an example, if a facility replaces 10 packaged HVAC units ranging in size from 3 to 10 tons, an engineer should attempt to install meters on one of the smaller units and one of the larger units, as well as units on different schedules and serving different end uses. In an idealized case in which five 3-ton units serve five similar small buildings in a county facility campus and five 10-ton units serve one large building in the same campus, a reasonable approach is to meter one of the 3-ton units and one of the 10-ton units.

- In all cases, the number of power meters installed at any site should be minimized while attempting to maximize the quality and utility of the collected data.

Attachment C:
Simulation Model-Based Analysis

This summary outlines the general data collection and simulation modeling procedures common to all model-based analyses.

Evaluating measures with a building simulation approach entails building a representative model of an affected facility and altering only a few select parameters that differentiate the baseline and installed case equipment. In contrast to spreadsheet-based analyses, which are conducted by isolating the measure of interest, simulation analyses require that a wide range of secondary building data are collected to inform the models. These data directly affect the loads imposed on both the base case and installed case models in the subsequent savings analysis.

With this consideration in mind, data related to the following building construction and operations characteristics should be collected for any commercial building modeling effort:

Building shell properties

- Shell dimensions and orientation
- Wall R-values, roof R-values, roof color (affects absorptivity and emissivity)
- Window types, dimensions, orientations, U-values, and solar heat gain coefficients (SHGC) (if available)
- Zoning (for HVAC)
- Plugs loads (computers, monitors, copy machines, refrigerators, coffee machines, and so forth) and plug-load schedules
- Lighting loads (lighting power density [LPD]) and lighting schedules
- Occupancy density and schedules
- Process loads and schedules
- HVAC system heating and cooling set points and scheduling
- Fan operating strategies (constant, cycling, nighttime setback, and so forth)

Using these data, in addition to any measure specific data, the baseline and as-built models can be constructed using eQuest, EnergyPlus, or any other building simulation software. Depending on the budget allocated to a given site, it may not be reasonable to extend the modeling effort to calibration. If, however, the project has been allocated sufficient resources, then the model can be calibrated with metering data, EMS data, or possibly billing data. In the former cases, metered and/or EMS data can be used to directly calibrate specific end uses in the model. As an example, an eQuest model could be calibrated using air handler metered data by

adjusting model parameters until the modeled air-handler profile matches the metered profile (within reason). Savings can then be assessed by running the calibrated post implementation model and the base case model with TMY3 weather and calculating the difference in annual energy consumption.

If using billing data for calibration, calibrate the *whole building*. The billing data approach requires calibrating the pre-implementation model, since a year's worth of post install billing data will not be available for any of the ECAA-ARRA or EECBG projects. This approach is in contrast to the metered data calibration approach, which requires calibrating the post implementation model.

Using a calibrated modeling approach is taking a calculated risk. Occasionally, it is very difficult to calibrate a given model to desired tolerances. In some cases, days can be spent on a calibration task that was originally anticipated to take a few hours. As a result, calibrated models should be proposed only for sites with multiple interacting measures, or measures that cannot be readily evaluated using other, more straightforward approaches.

Attachment D:
Sample Evaluation Plans

Example Plan 1:

Site Specific Plan – Del Norte County (001-10-ECE-ARRA)

This project is for the replacement and repair of various heating units serving the Del Norte jail facility. A total of nine measures were implemented at this site. The measures include the installation of high efficiency liquid petroleum gas (LPG) furnaces, replacement or repair of economizer units, and replacement of the existing domestic hot water (DHW) boilers with LPG condensing DHW heaters. Below is a list of all nine measures as described in the documents provided to DNV KEMA.

1. Install new LP gas condensing furnaces in place of MZ-4 in roof top penthouse (4-zones)
2. Install a heat recovery unit on roof for 100 percent outside air unit #MZ-4
3. Install new LP gas condensing furnaces in place of MZ-6 in basement (6-zones)
4. Repair and replace economizer and add new premium efficiency motor to return fan
5. Install new LP gas condensing furnaces in place of AHU-54 in basement (3-zones)
6. Install return air and economizer to AHU-54 system
7. Install a new LPG condensing DHW heater for the jail's old section DHW
8. Replace two rooftop furnaces with new LPG condensing furnaces
9. Install two new LPG condensing DHW heater for the jail's new section DHW

The contractor estimated energy saving using bin analysis coupled with general assumptions on the heating equipment's operation. Major parameters used in the algorithm include nameplate data such as capacity, airflow rate, and efficiency along with assumptions for the return air temperatures across different outside air temperature bins. Overall, the analysis appears reasonable. The same algorithms will be used in the evaluation's calculations but will be enhanced using spot combustion efficiency measurements and logged data at the mixing boxes where feasible.

During the site audit, all major end use equipment will be verified by examining their nameplate data. The major equipment for this site include the LPG furnaces (13 total based on the calculations provided) and (three total) DHW heaters. The economizer operations for the different heating systems will also be examined for functionality. The site audit will also include spot measurements on the hot water heaters and furnaces. In addition, temperature sensors will be placed at the HVAC mixing boxes along with a weather station measuring outside air in order correlate outside air temperature with the mixed air temperatures seen at the heating coil. This information will be used to inform the final energy calculations.

Example Plan 2

SD101 – DMV Oakland Coliseum Field Office

This project consisted of an interior and exterior lighting retrofit. According to the original project documentation, 24 occupancy sensors were slated for installation in addition to 141 T8 fixtures and 4 compact florescent lamps (CFLs). Additionally, 41 exterior high intensity discharge (HID) fixtures were to be replaced with induction fixtures. The evaluation approach for these lighting measures will follow the process outlined in the "Lighting Retrofits and Lighting Controls" general procedure summary.[7]

In addition to the lighting measures, VFDs were proposed for the building's air handlers. Based on available project documentation, it's unclear if this measure was ultimately implemented. Nonetheless, DNV KEMA has been supplied with the energy simulation models used to project energy savings from this measure. If this measure was implemented, then savings will be calculated using an updated version of the energy model revised based on building data collected on-site in accordance with the "Building Simulation Modeling Generalized Approach" in the *ECAA and EECBG: Data Collection Field Measurement, and Site Analysis Procedures*.[8] If air handler related EMS data are available (power, outside air flow, supply air temperature), these data will also be collected to assist in calibrating the air handler end use. If EMS power data related to the air handlers are not available, true power meters will be installed for a three to four week period to observe air handler operation. These data will then be used to calibrate the air handler end use in the building simulation model. The calibration will be completed by adjusting air handler parameters (for example, minimum flow rate and maximum power) and secondary variables, such as plug loads, that affect air handler loads.

Example Plan 3

Site Specific Plan – Albany Streetlighting (021-09-ECE-ARRA)

This project is for the replacement of street lights in the city of Albany. HPS lamps at various wattages were replaced with LED lamps. Energy savings are achieved from replacing the high wattage HPS lamps with the more efficient LED lamps. Per the project file, a total of 640 lamps were replaced in Albany with financing coming from both the Federal Government and the State of California. Out of the total replaced lamps, 451 were replaced under the ECAA loan program.

The evaluator plans to calculate the energy savings from this measure using a simple spreadsheet calculation method. Inputs include pre-existing and installed fixture wattages, quantities, and operating hours. The evaluator will conduct a short interview with the site contact to verify hours of operation and existing fixture types. The evaluator will visually verify

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7 ECAA and EECBG: Data Collection Field Measurement, and Site Analysis Procedures.

8 Ibid.

the fixture installation and perform a count of the LED streetlights throughout the city. Attempts to verify all the lighting fixtures will not be feasible due to the large quantity of fixtures installed. A smaller sample of a few hundred will be verified during the site visit. The sample will be selected across the city rather than focusing on any one location and will take into account different LED fixture wattages.

APPENDIX C:
Participant In-depth Interview Guide

Energy Efficiency and Conservation Block Grant (EECBG)

Decision Maker Survey

Interview Date:

Name of Interviewer:

Name of Interviewee:

Decision Maker's Organization:

EECBG Project Number:

ECAA Loan Number (if applicable):

Introduction

Hello. I'm contacting you from DNV KEMA, an energy efficiency consulting firm on behalf of the California Energy Commission as part of the evaluation of the Energy Efficiency and Conservation Block Grant (also called EECBG) program. We are interviewing EECBG participants to gain a better understanding of why they decided to install energy efficiency measures with funding from this grant program. We would also like your feedback on your satisfaction with the program, and your assessment of job creation.

The interview and any information that is provided will remain strictly confidential. We will not identify or attribute any of your comments or organization information

CONFIRMATION OF CORRECT RESPONDENT/ WARM-UP QUESTIONS

W1. May I please speak with **<%CONTACT>**?.According to our records, your organization implemented a project involving.**<%MEASURES>** on approximately **<%INSTALL_DATE>,** is that correct?

W2. I was told by**<REFERENCE NAME**> that you were the most knowledgeable and the most involved with the decision to implement the project. Is that correct?

[IF YES, SKIP TO W4.

IF NO, CONTINUE]

W3. Who would be the person most knowledgeable about the decision to implement the energy efficiency project that I just described?

Record <NEW CONTACT NAME> _____

and ask: May I speak with him/her?

W4. What was your specific role in the project? _____

W5. Were others involved with the project decision making, particularly the go/no-go decision? If so, what are their names and contact information?

Name_____Phone:_____

W6. First, as I mentioned previously, our records indicate there was a project implemented at **<%SITE NAME>** consisting of.**<%MEASURES>** ..**[MENTION THE PROJECT DETAILS, INCLUDING MEASURE NAME(S) AND QUANTITIES, DATES IF KNOWN]**. Was this the project you were involved with?

1	Yes	Continue
2	No	Probe further until reconciled
88	Don't know	Can you refer me to someone that would know?

W7..Were all of these measures installed as just described?

1 Yes
2 Yes, but the measure count is different _____(record here)
3 No Probe further until reconciled (such as final measure details are confirmed)

77 Other (RECORD VERBATIM)

88 Don't know

99 Refused

W8. In deciding to do a project of this type, there are usually a number of reasons why it may be undertaken. In your own words, can you tell me why your organization decided to implement this project? Were there any other reasons?.**DO NOT READ**

1 To replace old or outdated equipment
2 As part of a planned remodeling, build-out, or expansion

3 To gain more control over how the equipment was used
4 The maintenance downtime and associated expenses for the old equipment were too high
5 Had process problems and were seeking a solution
6 To improve measure performance
7 To improve the product quality
8 To comply with codes set by regulatory agencies
9 To improve facility safety
10 To comply with government policies regarding regular/normal maintenance/replacement policy
11 To get funding from the program
12 To protect the environment
13 To reduce energy costs
14 To reduce energy use/power outages
15 To update to the latest technology
77 Other (RECORD VERBATIM) _____

88 Don't know

99 Refused

W9. Were you actively involved in the block grant for **<%SITE NAME>?**

1 Yes Continue

2 No Can you refer me to someone that would know?

Name:_____Phone:_____

A. Attribution QUESTIONS

A1. When and how did the idea for this project originate?

DO NOT READ PROMPTS

1. Internally proposed
   Outside vendor or consultant (Probe: If applicable, was this person provided by the
   a. Energy Commission,
   b. a Utility Program,
   c. a local government program,
   d. a nonprofit,
   e. some other type of Program or

f. non-program affiliated?)\

2. Audit (Probe:
   a. Energy Commission
   b. other program or
   c. non-program)?
3. Information provided by the Energy Commission
4. Part of a larger modernization or remodeling effort
5. Part of an expansion

77. Other _____**(RECORD VERBATIM)**

88. Don't Know, Can't remember

A2..What was or were the roles for the EECBG Program in making this project happen.

1. Funding, essential (was needed to move project forward),
2. Funding, helpful,
   a. (project may have proceeded without it, but loan helped somewhat)
3. Funding, non-essential,(loan did not influence implementation)

77. Other _____ **(RECORD VERBATIM)**

88. Don't Know, Can't remember

If this project was funded by both an EECBG ARRA block grant and an ARRA EECA loan, ask question A2a:

A2a..I understand that this city/county has both block grant and a loan from the Energy Conservation Assistance Account (which you may know as an ECAA loan)..What was or were the roles for the combined EECBG and ECAA Loan programs in making this project happen.

1. Funding, essential (was needed to move project forward),
2. Funding, helpful,
   a. (project may have proceeded without it, but loan helped somewhat)
3. Funding, non-essential,(loan did not influence implementation)

A3. Using a scale from 1 to 5, where 1 is "Not at all influential" and 5 is "Very influential" How influential was the EECBG Program to the implementation of the project,

(Make sure it is consistent with the responses above)

1. Not at all influential

2.
3.
4.
5. Very influential

A4. Without assistance from the EECBG Program, the project

1. Would have been implemented exactly the same at exactly the same time
2. Would have been implemented at the same time but with less efficient equipment
3. Would have been delayed until another funding source was located or the existing equipment failed.
4. Would not have proceeded
77. Other _____**(RECORD VERBATIM)**

A5. Was the project "co-funded" with other federal funding, state funding, utility or third party energy efficiency program incentives?

1 Yes **(continue)**

2 No **(Skip to F1)**

88 Don't know (If you don't who would be the person that would know?)

A6..What other co-funding was obtained for this project in addition to the EECBG grant? (Include all that apply)

1 Utility funding **(continue to A7**)
2 ARRA Federal program funding **(continue to A7)**
3 Other non-ARRA Federal program funding **(continue to A7)**
4 Other state funding**(continue to A7)**
88 None. **(skip to F1)**
89 Don't know (If you don't who would be the person that would know?_____) **(skip to F1)**

Co-Funding Questions (Ask for each source of Co-Funding)

A7. What were the roles for the Co-funding source **(source #).**

1. Funding, essential (was needed to move project forward),
2. Funding, helpful, -
   a. (project may have proceeded without it, but this co-funding source helped somewhat)
3. Funding, non-essential,(this.co-funding source did not influence implementation)

77. Other _____ **(RECORD VERBATIM)**
88. Don't Know Can't remember

A8. Using a scale from 1 to 5, where 1 is "Not at all influential" and 5 is "Very influential" How influential was the Co-funding program **(source #)**.to the implementation of the project

(Make sure it is consistent with the responses above)

1. Not at all influential
2.
3.
4.
5. Very influential

A9. Without participation in and influence of the co-funding program **(source #)** that co-funded the project, the project

1. Would have implemented exactly the same at exactly the same time
2. Would have implemented at the same time but with less efficient equipment
3. Would have been delayed until another funding source was located or the pre-existing equipment failed.
4. Would not have proceeded

77. Other _____**(RECORD VERBATIM)**
88. Don't know, can't remember

Repeat questions for A-7 to A9 for Each Co-Funding Source

Question	CF Source 1	CF Source 2	CF Source 3	CF Source 4
Source Name				
A7				
A8				
A9				

F. Financial BATTERY (ASK ALL)

F1. Is there a criteria that your city/county use before you update your energy equipment? (Probe: such as group relamping or HVAC upgrade every 10 years? Or Rate of return on investment should be 3 years? Or payback should be 10 years?)

77 RECORD VERBATIM_____

88 Don't know

99 Refused

F2. What, if any, financial calculations does your organization make before proceeding with a project like this one?

77 RECORD VERBATIM_____

88 Don't know

99 Refused

F3. [IF PAYBACK OR RETURN ON INVESTMENT MENTIONED] Using a scale of 1 to 5, where 1 is very difficult and 5 is not difficult at all, How difficult or easy was it to develop a project that met the required payback period in order to qualify for the EECBG loan? ?

1. Very difficult
2.
3.

4.

5. Not difficult at all

88 Don't know

99 Refused

[If 1 or 2, ask: What made it difficult? RECORD VERBATIM_____]

F4. How often does your organization consider the entire life-cycle cost of the equipment, including energy costs, maintenance cost, when purchasing equipment? Would you say it was **[read unbracketed items, select one]:**

1 Never,
2 Rarely,
3 Sometimes,
4 Most of the time, or
5 Always
88 [Don't know]

99 [Refused]

Ask these questions for each measure or measure group:

F5. Next we would like to know about the age and condition of the equipment that was replaced. Approximately when was the old equipment purchased?

1 Record Verbatim _____
88 [Don't know]

99 [Refused]

F6. On the average, how many years do you normally use such equipment?

1 Record Verbatim _____

88 [Don't know]

99 [Refused]

F7. Which of the following best describes the condition of the existing equipment when it was replaced?

1 Fully functional
2 Fully functional but with significant problems
3 Non-functional
88 [Don't know]

99 [Refused]

Repeat questions for F5 to F6 for Each Measure

Question	M1	M2	M3	M4
Measure Name				
F5 –equip age				
F6 – years of use				
F7 - condition				

Question	M5	M6	M7	M8
Measure Name				
F5 –equip age				
F6 – years of use				
F7 - condition				

S. Satisfaction Section

Next I have some questions about your satisfaction with different aspects of this program. Using a scale of 1 to 5 where 1 = Very dissatisfied and 5= Very satisfied, how dissatisfied or satisfied are you with the:

	Very Dissatisfied Very Satisfied	
C1. Equipment installed as part of this project	1 2 3 4 5	NA
C2. Loan amount received for the project	1 2 3 4 5	NA
C3. Loan structure and amortization schedule	1 2 3 4 5	NA

Next I have some questions about the difficulty or ease of complying with various requirements of this program.

On a scale of 1 to 5, where 1 is very difficult and 5 is not difficult at all, how difficult was it to comply with the:

	Very Difficult Not Difficult at all	
C4. Grant application requirements	1 2 3 4 5	NA

If difficult or very difficult (1or 2), Can you please elaborate?

_____

_____

C5. Davis Bacon Act (define if needed)	1 2 3 4 5	NA

If difficult or very difficult (1or 2), Can you please elaborate?

_____
_____

C6. Buy American Act requirements 1 2 3 4 5 NA

If difficult or very difficult (1or 2), Can you please elaborate?

_____
_____

C7. National Historic Preservation Act 1 2 3 4 5 NA

If difficult or very difficult (1or 2), Can you please elaborate?

_____
_____

C8. Waste Management requirements 1 2 3 4 5 NA

If difficult or very difficult (1or 2), Can you please elaborate?

_____
_____

C9. Reporting Requirements to the Energy Commission 1 2 3 4 5 NA

If difficult or very difficult (1or 2), Can you please elaborate?

_____
_____

Next I have some questions about your satisfaction with your interactions with the Energy Commission. On a scale of 1 to 5, where 1 is very dissatisfied and 5 is very satisfied, how dissatisfied or satisfied were you with the:

Very Dissatisfied Very Satisfied

C10. Energy Commission's project management of the loan?

1 2 3 4 5 NA

C11. Communications with the Energy Commission's staff 1 2 3 4 5 NA

C12. Technical assistance from Energy Commission to develop projects

1 2 3 4 5 NA

C13..Do you have any comments or suggestions on how to improve the EECBG loan program?

_____

_____

J. Job Creation

J1. You've accepted funding for the EECBG grant under the ARRA program. I'd like to ask you about how this project has affected jobs at your operation. Are you the most knowledgeable person about jobs created or retained related to the EECBG project?

1 Yes
2 No (ask J1a)
77 Other (RECORD VERBATIM)_____ (ask J1a)
_____
88 Don't know (ask J1a)

99 Refused

J1a. If not, who would be the person most knowledgeable about the decision to implement the energy efficiency project that I just described?

(Record Contact Name and Contact Information)

J2. Were any jobs retained because of this project, that perhaps would have been eliminated if the project did not go forward?

1. Yes(Record Number)
2. No
   77 Other (RECORD VERBATIM)_____
   88 Don't know

   99 Refused

J3..Were additional people hired retained because of this project?

1. Yes(Record Number)
2. No
   77 Other (RECORD VERBATIM)_____

88 Don't know

99 Refused

J4..Do you know of jobs outside your operation that were retained because of the project?

1 Yes (Record Number)
2 No
77 Other (RECORD VERBATIM)_____
88 Don't know

99 Refused

J5..Do you know of jobs outside your operation that were added because of the project?

1 Yes (Record Number)
2 No
77 Other (RECORD VERBATIM)_____
88 Don't know

99 Refused

J6..Describe how the ARRA funding created jobs (probe, request anecdotes)

1 Layoffs avoided (RECORD Number and ADDITIONAL DETAILS VERBATIM)
2 Staff retained (RECORD Number and ADDITIONAL DETAILS VERBATIM)
3 New hires (RECORD Number and ADDITIONAL DETAILS VERBATIM)
4 Contract hires (RECORD Number and ADDITIONAL DETAILS VERBATIM)
5 Jobs for contractors or other outsiders (RECORD ADDITIONAL DETAILS VERBATIM)
77 Other (RECORD VERBATIM)
88 Don't know

99 Refused

J7. What type of jobs were added or retained? What skills were required? (probe, don't read the list) Fill out the table:

Job Number	Job Type	Job Skills	Industry Category	Permanent or Temporary

(don't read this list – but fill in for each line after the survey is complete)

1 Administration
2 Administration (Sales)
3 Architecture and Engineering
4 Building Envelope (Construction Trades)
5 Building Envelope (Performance Trades)
6 Management (Blue-Collar)
7 Management (White-Collar)
8 Manufacturing
9 Mechanical and Electrical Trades
77 Other (RECORD VERBATIM)
88 Don't know

99 Refused

Now I'd like to get your personal perspective on jobs.

J8.Is there anything we haven't talked about that you found interesting and would like to share related to jobs as part of your experience in the EECBG Program?

(RECORD VERBATIM)

_____
_____

SP. SPILLOVER QUESTIONS [ASK ONLY IF Program Influence response A4 was somewhat or very influential]

SP1 Did you implement any additional energy efficiency measures at your organization that were directly influenced through your participation in the EECBG Program that did not receive incentives, grants or loans through any utility or government program?

1 Yes

SP2

2 No THANK AND TERMINATE

88 Refused THANK AND TERMINATE

99 Don't know THANK AND TERMINATE

SP2 Would you please describe these measures in detail? Type of influence, details of the measure (count, efficiency, and so forth), what would have occurred in the absence of influence.

_____

_____

Thank and Terminate

APPENDIX D:
Population Level Program Tracking Data

Table 2: Program Savings Estimates in Tracking Data

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
CBG-09-001	Scotts Valley, City of	Lighting	46,976	0
		Total	46,976	0
CBG-09-002	Soledad, City of	Lighting	13,382	0
		Street Lighting	66,642	0
		Total	80,024	0
CBG-09-003	Santa Cruz, County of	HVAC - Chiller	24,900	0
		HVAC - Packaged Units	2,784	0
		HVAC Controls and Retrocommissioning	223,710	54,683
		Premium Efficiency Motor	19,731	0
		Premium Efficiency Motor with VFD	85,842	8,419
		Variable Frequency Drive	16,782	0
		Total	373,749	63,102
CBG-09-004	Greenfield, City of	Lighting	39,742	0
		Total	39,742	0
CBG-09-005	Albany, City of	Lighting	36,742	0
		Total	36,742	0
CBG-09-006	Placer, County of	HVAC - Boilers	0	2,250
		HVAC - Programmable Thermostats	20	17
		HVAC Controls and Retrocommissioning	447,772	6,300
		Lighting	299,722	0
		Lighting Controls	5,150	0
		Vending Machine Controls	40,079	0
		Total	792,743	8,567
CBG-09-007	King City, City of	Street Lighting	40,734	0
		Total	40,734	0
CBG-09-008	Laguna Woods, City of	Building Shell Measures	27,363	0
		Domestic Hot Water	1,310	0
		HVAC Controls and Retrocommissioning	19,440	58
		Lighting	21,235	0
		Lighting Controls	1,330	0
		Total	70,678	58
CBG-09-009	Marysville, City of	Street Lighting	35,208	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
		Total	35,208	0
CBG-09-010	San Joaquin, County of	HVAC - Chiller	293,309	0
		HVAC - Packaged Units	106,324	0
		Variable Frequency Drive	1,058,770	0
		Total	1,458,403	0
CBG-09-011	Ripon, City of	HVAC - Chiller	63,421	0
		HVAC - Packaged Units	5,980	200
		Lighting	5,499	0
		Total	74,900	200
CBG-09-012	Tehama, City of	HVAC - Packaged Units	12,801	0
		Total	12,801	0
CBG-09-013	Del Mar, City of	PC Power Management Measure	21,478	0
		Total	21,478	0
CBG-09-014	Lafayette, City of	Lighting	51,798	0
		Total	51,798	0
CBG-09-015	Inyo, County of	Lighting	350,575	0
		Vending Machine Controls	3,224	0
		Total	353,799	0
CBG-09-016	Coronado, City of	Lighting	117,688	0
		Lighting Controls	11,095	0
		Street Lighting	2,805	0
		Vending Machine Controls	10,971	0
		Total	142,559	0
CBG-09-017	Nevada, County of	Domestic Hot Water	726	6,736
		HVAC - Packaged Units	170,945	2,037
		HVAC Controls and Retrocommissioning	4,206	3,955
		Lighting	227,242	0
		Total	403,119	12,728
CBG-09-018	San Juan Capistrano, City of	Street Lighting	35,719	0
		Total	35,719	0
CBG-09-019	La Verne, City of	HVAC - Packaged Units	22,000	0
		HVAC Controls and Retrocommissioning	17,171	0
		Lighting	39,852	0
		Traffic Signals	366,925	0
		Total	445,948	0
CBG-09-020	Calaveras, County of	HVAC Controls and Retrocommissioning	15,319	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
		Lighting	163,141	0
		Total	178,460	0
CBG-09-021	Merced, County of	Lighting	393,230	0
		Total	393,230	0
CBG-09-022	Hollister, City of	HVAC - Packaged Units	9,833	0
		Lighting	22,404	0
		Street Lighting	96,229	0
		Total	128,466	0
CBG-09-023	Lathrop, City of	HVAC - Packaged Units	11,630	0
		Lighting Controls	12,984	0
		Traffic Signals	9,713	0
		Total	34,327	0
CBG-09-025	East Palo Alto, City of	Lighting	70,361	0
		Street Lighting	0	0
		Total	70,361	0
CBG-09-026	Mono, County of	HVAC Controls and Retrocommissioning	42,596	113
		Lighting	1,925	0
		Total	44,521	113
CBG-09-027	San Marino, City of	HVAC - Packaged Units	45,936	608
		Total	45,936	608
CBG-09-028	El Paso de Robles, City of	Lighting	68,328	0
		Total	68,328	0
CBG-09-029	Yucca Valley, Town of	HVAC - Packaged Units	12,231	0
		Lighting	22,974	0
		Lighting Controls	901	0
		Total	36,106	0
CBG-09-030	Siskiyou County Economic Development Council	Building Shell Measures	66,853	0
		HVAC - Programmable Thermostats	3,726	0
		HVAC Controls and Retrocommissioning	20,671	0
		Lighting	116,625	0
		Premium Efficiency Motor	58,968	0
		Vending Machine Controls	3,660	0
		Total	270,503	0
CBG-09-031	Oakley, City of	Lighting	100,556	0
		Total	100,556	0
CBG-09-032	Foster City, City of	Lighting	149,397	0
		Total	149,397	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
CBG-09-034	Tehama, County of	HVAC - Packaged Units	3,901	25,170
		HVAC - Programmable Thermostats	15,474	3,169
		Lighting	54,272	0
		Total	73,647	28,339
CBG-09-035	Yolo, County of	HVAC Controls and Retrocommissioning	101,007	2,636
		Lighting	6,000	0
		Total	107,007	2,636
CBG-09-036	Seaside, City of	Lighting	122,898	0
		Street Lighting	89,938	0
		Total	212,836	0
CBG-09-037	Dixon, City of	Street Lighting	54,019	0
		Total	54,019	0
CBG-09-038	Walnut, City of	HVAC - Packaged Units	6,589	0
		HVAC Controls and Retrocommissioning	185,038	0
		Lighting	121,013	0
		Total	312,640	0
CBG-09-039	Loma Linda, City of	Lighting	122,640	0
		Total	122,640	0
CBG-09-040	Menlo Park, City of	Street Lighting	15,100	0
		Total	15,100	0
CBG-09-041	Beaumont, City of	HVAC - Packaged Units	17,448	179
		HVAC - Programmable Thermostats	4,435	238
		Lighting	65,506	0
		Lighting Controls	12,194	0
		Street Lighting	21,024	0
		Total	120,607	417
CBG-09-042	Burlingame, City of	Lighting	204,414	0
		Lighting Controls	0	0
		Street Lighting	44,999	0
		Total	249,413	0
CBG-09-043	Pinole, City of	Street Lighting	39,484	0
		Total	39,484	0
CBG-09-044	Fairfax, Town of	Street Lighting	11,261	0
		Total	11,261	0
CBG-09-045	Goleta, City of	Lighting	28,021	0
		Lighting Controls	53,446	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
		Street Lighting	47,589	0
		Total	129,056	0
CBG-09-046	Norco, City of	Lighting	154,570	0
		Total	154,570	0
CBG-09-047	Willows, City of	Lighting	39,289	0
		Total	39,289	0
CBG-09-048	Calimesa, City of	HVAC - Heat Pump	1,305	0
		HVAC - Packaged Units	8,400	87
		Lighting	19,604	0
		Lighting Controls	3,319	0
		Total	32,628	87
CBG-09-049	Orland, City of	Air Conditioning	2,311	46
		HVAC - Packaged Units	7,876	305
		Total	10,187	351
CBG-09-050	Lemoore, City of	Lighting	49,857	0
		Total	49,857	0
CBG-09-051	Hercules, City of	Street Lighting	40,195	0
		Total	40,195	0
CBG-09-052	Benicia, City of	Lighting	130,392	0
		Total	130,392	0
CBG-09-053	Laguna Hills, City of	Air Conditioning	3,374	0
		HVAC - Packaged Units	16,232	0
		Lighting	7,894	0
		Lighting Controls	1,051	0
		Traffic Signals	316,897	0
		Variable Frequency Drive	44,111	0
		Total	389,559	0
CBG-09-054	Desert Hot Springs, City of	HVAC - Packaged Units	8,103	404
		Lighting	23,762	0
		Traffic Signals	259,610	0
		Total	291,475	404
CBG-09-055	Dinuba, City of	Lighting	68,214	0
		Street Lighting	38,719	0
		Total	106,933	0
CBG-09-056	Duarte, City of	HVAC Controls and Retrocommissioning	38,444	556
		Lighting	121,755	0
		Total	160,199	556
CBG-09-057	Laguna Beach, City of	HVAC - Packaged Units	39,026	0
		Lighting	127,639	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
		Total	166,665	0
CBG-09-058	Artesia, City of	HVAC - Packaged Units	1,414	0
		Total	1,414	0
CBG-09-059	Belmont, City of	Lighting	116,633	0
		Total	116,633	0
CBG-09-060	Larkspur, City of	Street Lighting	41,849	0
		Total	41,849	0
CBG-09-061	Brawley, City of	Variable Frequency Drive	58,657	0
		Total	58,657	0
CBG-09-062	Windsor, Cotati, and Cloverdale Collaborative	Street Lighting	58,218	0
		Total	58,218	0
CBG-09-063	Patterson, City of	Lighting	71,643	0
		Premium Efficiency Motor	4,400	0
		Traffic Signals	22,645	0
		Total	98,688	0
CBG-09-064	San Benito, County of	HVAC - Chiller	51,232	0
		Lighting	47,478	0
		Street Lighting	9,697	0
		Total	108,407	0
CBG-09-065	Piedmont, City of	Lighting	23,596	0
		Total	23,596	0
CBG-09-066	Grover Beach, City of	Lighting	71,452	0
		Total	71,452	0
CBG-09-067	American Canyon,City of	Street Lighting	67,255	0
		Total	67,255	0
CBG-09-068	Signal Hill, City of	Premium Efficiency Motor	16,172	0
		Total	16,172	0
CBG-09-069	Canyon Lake, City of	HVAC - Packaged Units	4,753	0
		HVAC - Programmable Thermostats	1,456	0
		Lighting	26,851	0
		Lighting Controls	5,033	0
		Total	38,093	0
CBG-09-070	Clayton, City of	Street Lighting	57,740	0
		Total	57,740	0
CBG-09-071	Los Alamitos, City of	Lighting	134,668	0
		Total	134,668	0
CBG-09-072	Grand Terrace, City of	Lighting	15,645	0
		Total	15,645	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
CBG-09-073	Farmersville, City of	HVAC - Chiller	40,583	0
		HVAC - Programmable Thermostats	3,102	461
		Total	43,685	461
CBG-09-074	Gonzales, City of	Street Lighting	44,698	0
		Total	44,698	0
CBG-09-075	San Juan Bautista, City of	Street Lighting	17,856	0
		Total	17,856	0
CBG-09-076	Live Oak, City of	Variable Frequency Drive	48,680	0
		Total	48,680	0
CBG-09-077	Villa Park, City of	HVAC - Packaged Units	13,273	0
		Lighting	12,980	0
		Lighting Controls	1,080	0
		Total	27,333	0
CBG-09-078	Agoura Hills, City of	Traffic Signals	35,248	0
		Total	35,248	0
CBG-09-079	Carpinteria, City of	Street Lighting	96,750	0
		Total	96,750	0
CBG-09-080	Mill Valley, City of	Climate Action Plan	0	0
		HVAC Controls and Retrocommissioning	3,166	0
		Lighting	104,006	0
		Total	107,172	0
CBG-09-082	Monterey, City of	Lighting	125,369	0
		Total	125,369	0
CBG-09-083	La Palma, City of	HVAC - Packaged Units	4,018	158
		Lighting	127,481	0
		Total	131,499	158
CBG-09-084	Oroville, City of	Street Lighting	72,708	0
		Total	72,708	0
CBG-09-085	El Cerrito, City of	Lighting	59,720	0
		Total	59,720	0
CBG-09-087	Brisbane, City of	Lighting	12,023	0
		Street Lighting	12,272	0
		Total	24,295	0
CBG-09-088	Colma, Town of	Lighting	14,368	0
		Total	14,368	0
CBG-09-089	Morro Bay, City of	Lighting	64,207	0
		Total	64,207	0
CBG-09-090	Fort Bragg, City of	Lighting	23,563	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
		Variable Frequency Drive	13,910	0
		Total	37,473	0
CBG-09-091	Emeryville, City of	Lighting	60,844	0
		Total	60,844	0
CBG-09-092	Loyalton, City of	Aeration unit	23,475	0
		Total	23,475	0
CBG-09-093	Livingston, City of	Premium Efficiency Motor	166,576	0
		Street Lighting	15,768	0
		Total	182,344	0
CBG-09-094	Millbrae, City of	Street Lighting	64,957	0
		Total	64,957	0
CBG-09-095	San Carlos, City of	Lighting	156,728	0
		Street Lighting	67,240	0
		Total	223,968	0
CBG-09-096	Big Bear Lake, City of	Lighting	28,543	0
		Lighting Controls	2,625	0
		Total	31,168	0
CBG-09-097	Gridley, City of	Street Lighting	24,173	0
		Total	24,173	0
CBG-09-099	Shasta Lake, City of	Variable Frequency Drive	30,982	0
		Total	30,982	0
CBG-09-101	Moraga, Town of	Building Shell Measures	18,000	1,200
		HVAC - Boilers	0	889
		HVAC - Packaged Units	5,193	3,833
		Lighting	16,273	0
		Lighting Controls	2,373	0
		Street Lighting	25,472	0
		Total	67,311	5,922
CBG-09-102	NCPA Collaborative	Lighting	126,629	0
		Street Lighting	16,787	0
		Total	143,416	0
CBG-09-103	Acterra	HVAC Controls and Retrocommissioning	44,677	12,000
		PC Power Management Measure	29,200	0
		Total	73,877	12,000
CBG-09-104	Imperial Beach, City of	Lighting	141,816	0
		Street Lighting	816	0
		Total	142,632	0
CBG-09-105	Santa Clara, County	HVAC Controls and	131,981	3,218

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
	of	Retrocommissioning		
		Lighting Controls	137,388	0
		Total	269,369	3,218
CBG-09-106	Tuolumne, County of	HVAC - Programmable Thermostats	5,461	40
		Lighting	290,658	0
		Total	296,119	40
CBG-09-107	Calistoga, City of	Lighting	10,730	0
		Total	10,730	0
CBG-09-108	Del Rey Oaks, City of	Building Shell Measures	0	534
		Lighting	13,703	0
		Total	13,703	534
CBG-09-109	Truckee, Town of	Domestic Hot Water	0	200
		HVAC - Programmable Thermostats	28,375	1,323
		Lighting	8,667	0
		Lighting Controls	524	0
		Premium Efficiency Motor	8,962	0
		Variable Frequency Drive	31,211	0
		Total	77,739	1,523
CBG-09-110	Blythe, City of	Lighting	117,000	0
		Total	117,000	0
CBG-09-111	Stanislaus, County of	Street Lighting	128,856	0
		Total	128,856	0
CBG-09-112	San Pablo, City of	Lighting	177,821	0
		Lighting Controls	50,072	0
		Street Lighting	43,321	0
		Total	271,214	0
CBG-09-113	La Habra Heights, City of	Air Conditioning	1,554	0
		HVAC - Furnace	0	5
		HVAC - Packaged Units	32,524	4
		Lighting	7,392	0
		Lighting Controls	1,841	0
		Total	43,311	9
CBG-09-114	Wildomar, City of	Street Lighting	27,594	0
		Traffic Signals	104,848	0
		Total	132,442	0
CBG-09-115	Loomis, Town of	Lighting	4,920	0
		Street Lighting	25,045	0
		Total	29,965	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
CBG-09-116	Pismo Beach, City of	Lighting	12,180	0
		Total	12,180	0
CBG-09-117	Marina, City of	Street Lighting	99,824	0
		Total	99,824	0
CBG-09-118	Corning, City of	Building Shell Measures	4,848	474
		HVAC - Furnace	0	1,477
		Lighting	26,127	0
		Total	30,975	1,951
CBG-09-119	Mammoth Lakes, Town of	HVAC - Boilers	0	4,730
		Total	0	4,730
CBG-09-120	Calipatria, City of	Air Conditioning	20,144	0
		HVAC - Packaged Units	6,846	0
		Lighting	25,309	0
		Total	52,299	0
CBG-09-121	Carmel-by-the-Sea, City of	HVAC - Packaged Units	3,994	416
		Lighting	13,945	0
		Total	17,939	416
CBG-09-122	San Anselmo, Town of	Lighting	39,315	0
		Total	39,315	0
CBG-09-123	Pacific Grove, City of	Lighting	25,523	0
		Street Lighting	30,905	0
		Traffic Signals	3,573	0
		Total	60,001	0
CBG-09-124	Atascadero, City of	HVAC - Packaged Units	131,010	0
		HVAC - Programmable Thermostats	22,598	0
		Lighting	7,965	0
		Premium Efficiency Motor	8,675	0
		Street Lighting	1,755	0
		Total	172,003	0
CBG-09-125	Pleasant Hill, City of	HVAC - Heat Pump	2,816	0
		HVAC - Programmable Thermostats	851	0
		HVAC Controls and Retrocommissioning	107,486	7,230
		Variable Frequency Drive	53,518	0
		Total	164,671	7,230
CBG-09-126	Marin, County of	Building Shell Measures	236,616	21,034
		HVAC - Boilers	0	16,541
		Lighting	75,039	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
		Ozone Laundry	0	7,148
		Street Lighting	235,910	0
		Total	547,565	44,723
CBG-09-128	Suisun City, City of	HVAC Controls and Retrocommissioning	61,587	0
		Lighting	148,428	0
		PC Power Management Measure	29,700	0
		Total	239,715	0
CBG-09-129A	Alameda, County of	Lighting	1,007,962	0
		Total	1,007,962	0
CBG-09-130	Needles, City of	Street Lighting	11,160	0
		Total	11,160	0
CBG-09-131	Sutter, County of	Lighting	51,073	0
		Street Lighting	15,718	0
		Total	66,791	0
CBG-09-132	Menifee, City of	Street Lighting	97,324	0
		Traffic Signals	15,770	0
		Total	113,094	0
CBG-09-134	Ventura County Collaborative	HVAC - Packaged Units	94,680	0
		Lighting	1,155,240	0
		Lighting Controls	142,850	0
		Street Lighting	91,673	0
		Total	1,484,443	0
CBG-09-135	San Joaquin Valley Unified Air Pollution Control District	Air Conditioning	82,702	0
		Domestic Hot Water	1,620	0
		HVAC - Packaged Units	17,344	0
		HVAC - Programmable Thermostats	7,520	0
		Lighting	2,202,806	0
		Lighting Controls	93,939	0
		Street Lighting	302,399	0
		Traffic Signals	1,577	0
		Total	2,709,907	0
CBG-09-136	San Joaquin Valley Unified Air Pollution Control District	Air Conditioning	38,175	0
		HVAC - Packaged Units	99,061	0
		HVAC - Programmable Thermostats	4,194	0
		Lighting	160,069	0
		Lighting Controls	1,714	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
		Premium Efficiency Motor	68,591	0
		Premium Efficiency Motor with VFD	274,960	0
		Street Lighting	762,847	0
		Variable Frequency Drive	194,187	0
		Total	1,603,798	0
CBG-09-137	Barstow, City of	Lighting	183,814	0
		Lighting Controls	0	0
		Street Lighting	4,030	0
		Vending Machine Controls	3,366	0
		Total	191,210	0
CBG-09-138	Saratoga, City of	Lighting	31,273	0
		Lighting Controls	8,661	0
		Total	39,934	0
CBG-09-139	San Fernando, City of	Lighting	22,956	0
		Street Lighting	59,124	0
		Traffic Signals	9,392	0
		Total	91,472	0
CBG-09-140	Imperial, County of	HVAC - Chiller	150,000	0
		HVAC - Programmable Thermostats	31,000	0
		HVAC Controls and Retrocommissioning	564,000	0
		Total	745,000	0
CBG-09-141	Hillsborough, Town of	Lighting	23,710	0
		Lighting Controls	0	0
		Premium Efficiency Motor	21,663	0
		Total	45,373	0
CBG-09-142	Westlake Village, City of	Lighting	45,078	0
		Total	45,078	0
CBG-09-143	Galt, City of	Street Lighting	101,266	0
		Total	101,266	0
CBG-09-144	Susanville, City of	Domestic Hot Water	159,879	(7,785)
		Total	159,879	(7,785)
CBG-09-145	Indian Wells, City of	Lighting	128,312	0
		Total	128,312	0
CBG-09-147	Lawndale, City of	HVAC Controls and Retrocommissioning	78,672	7,513
		Lighting	10,060	0
		Lighting Controls	28,070	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
		Total	116,802	7,513
CBG-09-149	Hermosa Beach, City of	Lighting	139,720	0
		Total	139,720	0
CBG-09-151	Rolling Hills Estates, City of	HVAC - Packaged Units	2,778	0
		HVAC Controls and Retrocommissioning	3,257	0
		Lighting	26,190	0
		Total	32,225	0
CBG-09-152	Twentynine Palms, City of	HVAC - Packaged Units	58,708	1,297
		Lighting	86,476	0
		Premium Efficiency Motor	7,228	0
		Total	152,412	1,297
CBG-09-153	Del Norte, County of	Domestic Hot Water	0	3,736
		HVAC - Furnace	12,056	7,247
		HVAC Controls and Retrocommissioning	(14,352)	1,565
		Total	(2,296)	12,548
CBG-09-154	Seal Beach, City of	HVAC Controls and Retrocommissioning	25,032	0
		Lighting	99,526	0
		Total	124,558	0
CBG-09-155	El Segundo, City of	Lighting	342,573	0
		Lighting Controls	205,343	0
		Total	547,916	0
CBG-09-156	Lake, County of	HVAC - Packaged Units	22,608	0
		HVAC - Programmable Thermostats	9,305	1,382
		Lighting Controls	41,160	0
		Total	73,073	1,382
CBG-09-157	Auburn, City of	Air Conditioning	1,720	0
		HVAC - Programmable Thermostats	388	0
		Lighting	0	0
		Street Lighting	37,879	0
		Total	39,987	0
CBG-09-158	Amador, County of	HVAC - Packaged Units	33,692	318
		Lighting	76,312	0
		Total	110,004	318
CBG-09-159	Santa Fe Springs, City of	HVAC - Heat Pump	247,338	0
		HVAC - Packaged Units	40,222	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
		Total	287,560	0
CBG-09-160	Winters, City of	HVAC - Packaged Units	9,121	0
		Lighting	11,600	0
		Total	20,721	0
CBG-09-161	Sebastopol, City of	Lighting	9,490	0
		Total	9,490	0
CBG-09-162	Calabasas, City of	Lighting	68,552	0
		Lighting Controls	2,645	0
		Vending Machine Controls	11,284	0
		Total	82,481	0
CBG-09-163	Glenn, County of	HVAC - Packaged Units	45,575	388
		Total	45,575	388
CBG-09-164	Mendocino, County of	HVAC - Packaged Units	7,719	161
		HVAC Controls and Retrocommissioning	41,061	2,934
		Lighting	389,451	0
		Total	438,231	3,095
CBG-09-165	Commerce, City of	Lighting	89,703	0
		Lighting Controls	3,421	0
		Total	93,124	0
CBG-09-166	Anderson, City of	Street Lighting	39,976	0
		Total	39,976	0
CBG-09-167	South El Monte, City of	HVAC - Packaged Units	7,462	257
		Lighting	119,672	0
		Vending Machine Controls	1,612	0
		Total	128,746	257
CBG-09-168	Jackson, City of	Lighting	6,363	0
		Total	6,363	0
CBG-09-169	Clearlake, City of	Building Shell Measures	79,184	(902)
		Lighting	53,038	0
		Traffic Signals	13,460	0
		Total	145,682	(902)
CBG-09-170	Placerville, City of	Lighting	56,739	0
		Total	56,739	0
CBG-09-171	Sierra Madre, City of	Lighting	54,914	0
		Lighting Controls	8,596	0
		Total	63,510	0
CBG-09-172	Orinda, City of	Street Lighting	19,084	0
		Total	19,084	0
CBG-09-173	Solana Beach, City of	HVAC - Heat Pump	70,958	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
		Total	70,958	0
CBG-09-175	Ridgecrest, City of	Lighting	155,172	0
		Total	155,172	0
CBG-09-176	Irwindale, City of	Lighting	30,422	0
		Total	30,422	0
CBG-09-177	El Dorado, County of	Lighting	352,015	0
		Premium Efficiency Motor	36	0
		Premium Efficiency Motor with VFD	15	0
		Variable Frequency Drive	375	0
		Total	352,441	0
CBG-09-178	Arroyo Grande, City of	HVAC - Packaged Units	5,354	263
		HVAC Controls and Retrocommissioning	23,815	822
		Lighting	20,445	0
		PC Power Management Measure	18,227	0
		Vending Machine Controls	1,874	0
		Total	69,715	1,085
CBG-09-179	Hawaiian Gardens, City of	Lighting	77,986	0
		Vending Machine Controls	6,344	0
		Total	84,330	0
CBG-09-180	South Lake Tahoe, City of	Lighting	176,515	0
		Lighting Controls	10,374	0
		Total	186,889	0
CBG-09-182	Rancho Mirage, City of	HVAC Controls and Retrocommissioning	1,188	0
		Lighting	89,528	0
		Vending Machine Controls	6,440	0
		Total	97,156	0
CBG-09-183	South Pasadena, City of	HVAC Controls and Retrocommissioning	23,697	0
		Traffic Signals	199,020	0
		Total	222,717	0
CBG-09-184	Los Gatos, Town of	Lighting	65,990	0
		Total	65,990	0
CBG-09-185	Guadalupe, City of	HVAC - Heat Pump	598	0
		Lighting	12,945	0
		Premium Efficiency Motor	3	0
		Variable Frequency Drive	23	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
		Total	13,569	0
CBG-09-186	Nevada City, City of	Lighting	14,350	0
		Lighting Controls	3,242	0
		Street Lighting	8,569	0
		Total	26,161	0
CBG-09-187	Holtville, City of	Air Conditioning	17,263	0
		HVAC - Programmable Thermostats	2,309	351
		Total	19,572	351
CBG-09-189	Adelanto, City of	Lighting	181,477	0
		Total	181,477	0
CBG-09-190	Yuba, County of	Lighting	414,729	0
		Premium Efficiency Motor with VFD	50,395	0
		Total	465,124	0
CBG-09-191	Ione, City of	Lighting	15,674	0
		Lighting Controls	832	0
		Total	16,506	0
CBG-09-192	Mariposa, County of	Air Conditioning	9,712	606
		Lighting	14,273	0
		Vending Machine Controls	1,813	0
		Total	25,798	606
CBG-09-193	Wheatland, City of	Lighting	27,050	0
		Total	27,050	0
CBG-09-194	Shasta, County of	HVAC - Chiller	231,227	0
		HVAC - Packaged Units	15,351	0
		HVAC Controls and Retrocommissioning	50,170	1,470
		Lighting	124,074	0
		Lighting Controls	73,446	0
		Total	494,268	1,470
CBG-09-195	Yountville, Town of	Building Shell Measures	0	462
		Domestic Hot Water	2,773	0
		HVAC - Packaged Units	6,301	118
		HVAC Controls and Retrocommissioning	8,712	0
		Lighting	17,774	0
		Lighting Controls	7,222	0
		Premium Efficiency Motor	2,784	0
		Street Lighting	52,242	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
		Total	97,808	580
CBG-09-196	St. Helena, City of	Lighting	1,725	0
		Lighting Controls	12,495	0
		Total	14,220	0
CBG-09-197	Solano, County of	Lighting	244,592	0
		Total	244,592	0
CBG-09-198	Northern Rural Training & Employment Consortium	HVAC - Packaged Units	0	182
		Lighting	72,016	0
		Premium Efficiency Motor	27,760	0
		Street Lighting	50,830	0
		Total	150,606	182
CBG-09-199	North Coast Integrated Regional Water Management Plan	Aeration unit	55,166	0
		Air Conditioning	5,727	0
		Building Shell Measures	0	62
		Domestic Hot Water	0	296
		HVAC - Furnace	3,381	2,691
		HVAC - Packaged Units	(8,125)	6,458
		HVAC Controls and Retrocommissioning	91,957	2,882
		Lighting	521,015	0
		Premium Efficiency Motor	44,439	4,030
		Premium Efficiency Motor with VFD	221,410	0
		Street Lighting	38,839	0
		Variable Frequency Drive	415,797	0
		Total	1,389,606	16,419
CBG-09-201	Williams, City of	Air Conditioning	4,147	0
		Lighting	9,527	0
		Total	13,674	0
CBG-09-202	La Canada Flintridge, City of	HVAC - Packaged Units	19,720	0
		Lighting	117,552	0
		Total	137,272	0
CBG-09-203	Red Bluff, City of	Street Lighting	49,687	0
		Total	49,687	0
CBG-09-204	Plumas, County of	Lighting	91,189	0
		Total	91,189	0
CBG-09-205	Lomita, City of	HVAC Controls and Retrocommissioning	19,517	0
		Lighting	87,099	0
		Total	106,616	0

Grant Number	Subrecipient Name	Measures	Ex Ante Electric Savings (kWh)	Ex Ante Natural Gas or Equivalent Savings (therms)
CBG-09-206	Beverly Hills, City of	HVAC - Packaged Units	11,750	154
		HVAC Controls and Retrocommissioning	88,241	0
		Lighting	227,859	0
		Premium Efficiency Motor with VFD	6,340	0
		Total	334,190	154
CBG-09-207	Half Moon Bay, City of	Lighting	188,727	0
		Lighting Controls	10,821	0
		Total	199,548	0
CBG-09-208	Lemon Grove, City of	Lighting	149,870	0
		Total	149,870	0
CBG-11-002	Marysville, City of	Lighting	335,000	0
		Total	335,000	0
CBG-11-003	East Palo Alto, City of	Lighting	94,870	0
		Total	94,870	0
CBG-11-004	Riverbank, City of	Lighting	430,800	0
		Total	430,800	0
CBG-11-005	Sausalito, City of	Lighting	110,000	0
		Total	110,000	0
CBG-11-006	Lemoore, City of	Lighting	232,349	0
		Total	232,349	0
CBG-11-007	Big Bear Lake, City of	Lighting	19,513	0
		Total	19,513	0
CBG-11-008	Shasta Lake, City of	Lighting	144,750	0
		Total	144,750	0
CBG-11-010	Foster City, City of	Lighting	710,280	0
		Total	710,280	0
CBG-11-011	Del Mar, City of	Lighting	31,000	0
		Total	31,000	0
CBG-11-012	Laguna Beach, City of	Lighting	810	0
		Total	810	0
CBG-11-013	Menlo Park, City of	Lighting	514,637	0
		Total	514,637	0
Grand Total			34,337,164	240,039

Source: DNV KEMA analysis

APPENDIX E:
On-Site Evaluation Reports

ON-SITE EVALUATION REPORT
Energy Efficiency and Conservation Block Grant (EECBG) Program

Santa Cruz, County of (CBG-09-003)

Site Summary

The County of Santa Cruz was awarded funds to implement a number of energy efficiency projects at three jail facilities and two buildings throughout the cities of Santa Cruz, Felton, and Watsonville. The EEMs included the conversion of heating hot water pumps to variable flow control, modifications to the air handling units to incorporate VFD and setback controls, addition of an ozone laundry system, replacement of a three ton packaged RTU, and the replacement of a chiller. All measures were found implemented except the ozone laundry system. This report focuses on the measures implemented only.

Ex post electric and gas energy savings were estimated at 588,776 kWh and 20,737 therms, respectively, for this project. This represents 158 percent and 33 percent of the ex ante estimates for electric and gas energy savings in Table 3. The higher energy savings calculated were primarily the result of EEM7 which when measured at the end-use equipment, showed much higher preretrofit energy consumption and lower retrofit energy consumption. For the gas energy savings estimates, DNV KEMA found that the ex ante estimate for the measure responsible for the majority of the gas savings (EEM2) overstated gas consumption at the facility based on established preretrofit billing data. The results, listed measure by measure, are shown in Table 3 below with further discussion by measure towards the end of this report.

Table 3: Energy Savings Summary

Measure	Ex Ante[9]			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 - Hot water pump VFDs (Main Jail)	19,731	Not reported	0.0	13,316	1.5	0.0	67%	N/A
EEM2 - Fan VFDs, motors, and controls (Main Jail)	59,789	Not reported	46,216	40,707	0.0	12,131	68%	26%
EEM3 - Packaged rooftop air conditioner replacement (Medium Security Jail)	2,784	1.13	0.0	1,291	2.2	0.0	46%	N/A
EEM4 - Fan VFDs, motors, and controls (Medium Security Jail)	23,105	Not reported	8,467	40,333	0.0	3,938	175%	47%
EEM5 - Hot water pump VFDs (Juvenile Hall)	16,782	Not reported	0.0	6,835	0.8	0.0	41%	N/A
EEM6 - Fan VFDs, motors, and controls (Juvenile Hall)	85,842	Not reported	8,419	52,578	6.0	4,668	61%	55%
EEM7 - VSD fans	140,816	Not reported	0.0	357,548	55.6	0.0	254%	N/A
EEM8 - Chiller retrofit	24,900	Not reported	0.0	76,168	32.7	0.0	306%	N/A
Total	373,749	1.1	63,102	588,776	98.8	20,737	158%	33%

Source: DNV KEMA analysis

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment is exceeded

9 Ex ante values come from the tracking database provided to KEMA by the Energy Commission.

The overall results from Table 4 yield a life-cycle energy savings of 9,212,480 kWh and 311,055 therms (Table 4) for Baseline 1. Under Baseline 2, the life-cycle energy savings is 8,405,335 kWh and 311,055 therms.

Table 4: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW years)	Natural Gas Energy Savings (Therms)
Baseline 1	9,212,480	1,646	311,055
Baseline 2	8,405,335	1,159	311,055

Source: DNV KEMA analysis

Project Description

The projects implemented in Santa Cruz county included projects in the city of Felton, Santa Cruz, and Watsonville. These affected three main jail facilities and two mental health buildings along Emeline Avenue. The jail facilities were the following: Main Jail, Medium Security Jail, and Juvenile Hall. Initially, two measures for ozone laundry was planned for installation at the Main Jail and the Minimum Security Jail Facility but these measures were not implemented because of concerns about payback. Ultimately, the following measures were implemented as part of the EECBG:

- EEM1 – At the Main Jail, constant speed pumps controlling the heating hot water were retrofitted with variable speed drives. The drives allow the pumps to reduce the flow of hot water flow as needed.
- EEM2 – At the Main Jail, four sets of supply and exhaust fans were retrofitted with variable speed drives. The motors were also replaced with high efficiency motors. Controls were installed that allowed for night time temperature setback and recycling of a portion of the exhaust air during cold weather conditions. Prior to the retrofit the units were constant speed and employed 100 percent outside air.
- EEM3 – At the Medium Jail Facility, an older 3-ton packaged RTU was replaced with a high efficiency unit.
- EEM4 – At the Medium Jail Facility, four sets of supply and return fans were retrofitted with variable speed drives. The motors were replaced with high efficiency motors. In addition, controls were set up to reduce the air handlers to 60 percent speed at night. Two other air handlers, which were not retrofitted with VFDs, were turned off to conserve energy at night and were included in the energy savings for the "controls" portion of this measure.
- EEM5 – At the Juvenile Hall Facility, constant speed pumps controlling the heating hot water were retrofitted with variable speed drives. The measure is similar to EEM1 except that it was employed at Juvenile Hall.

- EEM6 – At the Juvenile Hall Facility, VFDs were installed at five different supply/return fans on four HVAC systems. Energy savings come from a reduction of fan speeds due to the VFDs.
- At the 1400 building at Emeline Ave, six variable speed drives were installed on supply and return fans. In conjunction with the new building management system controls, the fan speeds and operating hours could be augmented and optimized to save energy.
- At the 1080 building, a new 100 ton rotary screw chiller was installed. This replaced a much older reciprocating chiller with similar capacity but that was past its useful life.

Ex Ante Savings

A feasibility report was provided in the project files for review. The electronic spreadsheet calculations were not included but the appendix listed the results and assumptions of the calculation methodology. The ex ante calculation methodology described below is based on this document.

EEM1: VFDs on hot water pumps (Main Jail)

For EEM1, the baseline case was a pump with a five horsepower motor running at constant speed for 8,760 hours a year. The power draw was estimated based on a motor efficiency of 0.82 and the nameplate horsepower (5). In the efficient case, the power draw was again estimated using an improved motor efficiency along with estimated power draw at different loading points. The pump loading points vary from 30 percent to 100 percent with respective power draws of 0.10 kW to 3.65 kW. The number of hours at which the pump operates at each point was estimated by the implementer.

EEM2: Fan VFDs, motors and controls (Main Jail)

The document provided suggested electric energy savings were based on the following general equation:

$$Energy = \frac{HP}{\eta} \times 0.746 \times hours$$

Where *HP* is the motor horsepower, η is the estimate on motor efficiency, *0.746* is a conversion factor, and *hours* are the estimated hours of operation.

In the baseline case, the annual hours of operation was assumed at 8,760 running at full load. In the proposed case, the fan power draw was augmented by a higher efficiency motor. The run hours in the proposed case is split between 5,110 hours at full speed and 3,650 hours at a reduced 60 percent speed. At the reduced speed, fan power was assumed to be lower based on fan affinity laws.

A few things should be noted about these calculations. The assumptions used are generalized and may not represent the actual system. For example, the baseline efficiencies are not the same as the existing nameplate motor efficiency and motor loading is assumed to be very high (95 percent). These values are also not backed by measurements and may not represent actual

operating conditions. Overall, the calculations are of low rigor and designed to provide a "ballpark" estimate.

Gas energy savings were determined by the following: Outside air temperature was assumed to require heating to 70°F. Degree-hour requirements were then calculated using average daily temperatures bins (for all the 24 hours of the day) for each month of the year. This value was input into the following algorithm to determine gas energy consumption:

$$Energy = \frac{1.10 \ \times DegreeHours \times CFM}{Boiler\ efficiency}$$

Where *1.10* is a conversion factor, *DegreeHours* is the calculated degree hour using average daily temperature bins, *CFM* is the total outside airflow rate (43,150 CFM), and *Boiler efficiency* is the assumed efficiency of the boiler heating the air (80 percent).

For the efficient case, air was assumed to be heated to 64 degrees, and the outside air dampers only allow 60 percent of the full airflow rate to enter the air handler at night. This has the effect of reducing the *CFM* and *DegreeHours* value and therefore the gas energy consumed.

Similar to the electric energy savings calculation, the gas energy savings calculation methodology used low rigor and was designed to provide a ballpark estimate of the gas savings. It should be noted that the binning method used is simplistic (uses average daily temperatures for each month versus an 8,760 analysis) and there is an error in the assumptions that do not reflect the proposed case conditions. For example, in the proposed case, a reduction in the degree hour calculation from 70 to 64 is meant to estimate night time setback. However, this change in the degree hour calculations affect both night time and day time hour bins and increased the reported gas energy savings.

EEM3: Packaged rooftop air conditioner replacement (Medium Security Jail)

The energy savings calculation used operating hours of the compressor, the unit's capacity, and its SEER value to estimate energy savings. The baseline energy consumption used the following equation:

$$Energy = \frac{EFLH \times Capacity}{1000 \times SEER}$$

Where *Energy* is the energy consumed (kWh), *EFLH* is the estimated full load hour of the unit (estimated at 1800), *Capacity* is the cooling capacity of the unit (27,000 Btu/h), and *1000* is a conversion factor, and *SEER* is the efficiency rating of the unit (9.6 for Baseline 1 for proposed).

For the proposed case, the energy consumed was reduced further by 25 percent as an estimate of the savings from the economizer. Total energy savings was calculated as the difference between the energy consumption of the baseline and proposed cases.

EEM4: Fan VFDs, motors and controls (Medium Security Jail)

These calculations were identical to EEM2 as described above except for some minor differences in the values used for airflow rates that were specific to this location.

EEM5: VFDs on hot water pumps (Juvenile Hall)

These calculations were identical to EEM1 with the exception of the horsepower used which was specific to this *location*. DNV KEMA notes that for EEM5, the calculations double count pump energy. The ex ante calculations for EEM5 is for two pumps operating at the same time but in reality only one pump is on at a time (with the second standing by as a backup).

EEM6: Fan VFDs, motors and controls (Juvenile Hall)

These calculations were identical to EEM2 as described above except for some minor differences in the values used for airflow rates and motor horsepower specific to this location.

EEM7: VFDs on supply and return fans (1400 Emeline)

Energy savings were calculated using generalized assumptions on fan power (based on the fan motor's horsepower ratings), fan load, and hours of operations. All fans were assumed to operate 3,640 hours per year. The hours of operation were split among fan loads which vary from 30 percent to 100 percent. Depending on which fan loads were considered, the power draw varied from 54 percent of full load to 102 percent of full load for the baseline "inlet vane" case. To calculate postretrofit energy consumption, the implementers used fan affinity laws to estimate power consumption using variable speed drives. Energy savings was the difference between the inlet vane fan controlled and VFD fan controlled cases.

EEM8: Chiller Replacement(1080 Emeline)

Energy savings were calculated using the following equation:

$$Savings = EFLH \times TONS \times (IPLV_{old} - IPLV_{new})$$

Where *Savings* is the energy savings in kWh, *EFLH* is the estimated full load operating hours assumed as 1000, *TONS* is the chiller tonnage at 100 tons, and *IPLV* is the integrated part load efficiency rating of the old and new chillers. The old chiller IPLV value was assumed at 0.77 kW/ton while the new is assumed at 0.521 kW/ton. The values were the implementer's estimates and do not represent either the actual operating hours of the chillers nor the efficiencies of the equipment in question.

Project Evaluation

DNV KEMA's evaluation for this project incorporated both pre and postretrofit conditions using data gathered via multiple site visits. While there are eight measures for this project, there are only three unique measures which were implemented at three separate buildings. The evaluation methodology presented here groups some of these measures together for brevity.

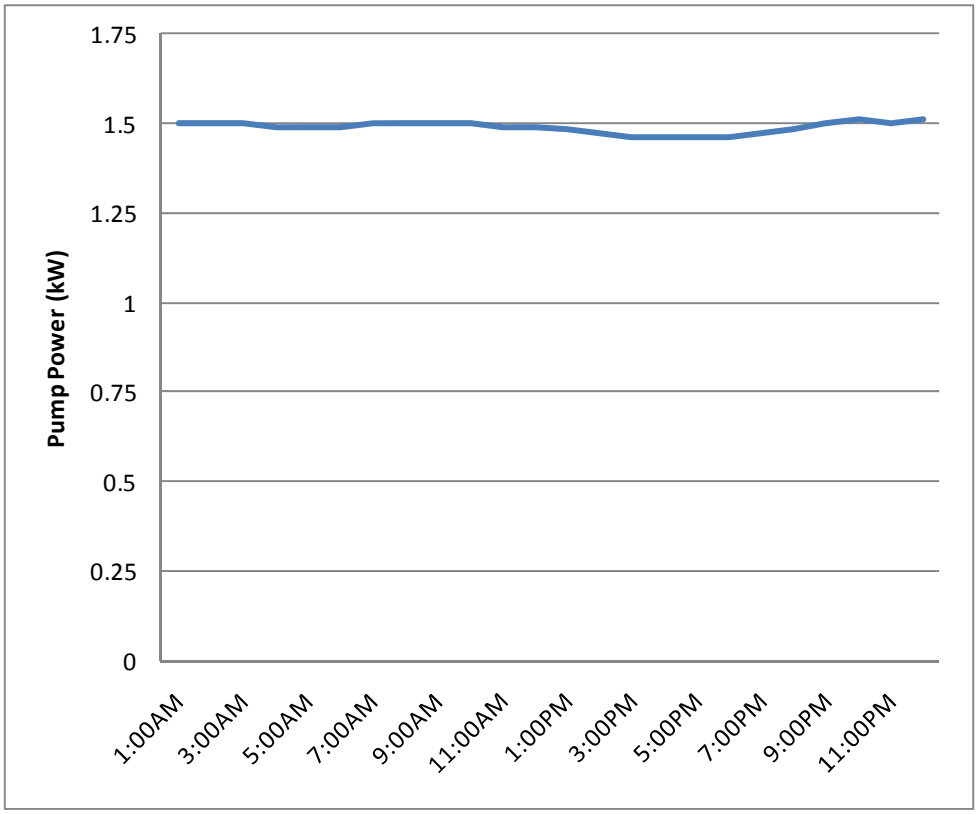
EEM1 & EEM5: VFDs on hot water pumps (Main Jail & Medium Security Jail)

Pre and Postretrofit data and analysis

A DNV KEMA field engineer visited the project's sites on November 15th, 2011 to monitor the pumps prior to the VFD retrofit in order to establish a baseline energy profile. Spot power measurements were taken of the hot water pumps at both the Main Jail and Medium Security Jail. A current transducer (CT) logger was placed at the incoming electrical lines of the pump which measures how often the pump is on; a power logger was not required since the pumps are expected to be constant speed. The data showed that the pump never turned off for the entire two weeks of monitoring.

After the VFDs were installed, the DNV KEMA engineer returned to monitor the pumps using a power logger (since power modulation is expected with VFDs). The VFDs reduced the input power of the pump by 50 percent. However, modulation was minimal (ranged from 1.41 to 1.6 kW) and can be approximated using an average daily power draw profile (Figure 7).

Figure 7: Average Daily Power Draw of Hot Water Pump at Main Jail over 5 Weeks Postretrofit



Source: DNV KEMA analysis

Based on this data, the energy consumption calculations for both pre and postretrofit cases used the same equation:

$$Energy = Power \times hours$$

Where *Energy* is the energy consumed in kWh, *Power* is the average power draw of the pumps and *hours* is the annual hours of operation.

Using data collected from the pre and postretrofit site visits, a total of 13,316 kWh and 6,835 kWh were saved for EEM1 and EEM5, respectively. Table 5 below lists the values used in the energy calculations and how the values were derived.

Pump Power Calculation Values and Sources

Table 5: Pump Power Calculation Values and Sources

Description	Preretrofit Power Draw (kW)	Preretrofit Hours of Operation	Source	Average Postretrofit Power Draw (kW)	Postretrofit Hours of Operation	Source
Hot water pump at Main Jail	3.01	8,760	Power measured and hours from monitored data	1.49	8,760	Power and hours from monitored data
Hot water pump at Juvenile Hall	1.54	8,760	Power is measured and hours assumed similar to pump at Main Jail	0.76	8,760	Hours and power reduction assumed similar to pump at Main jail

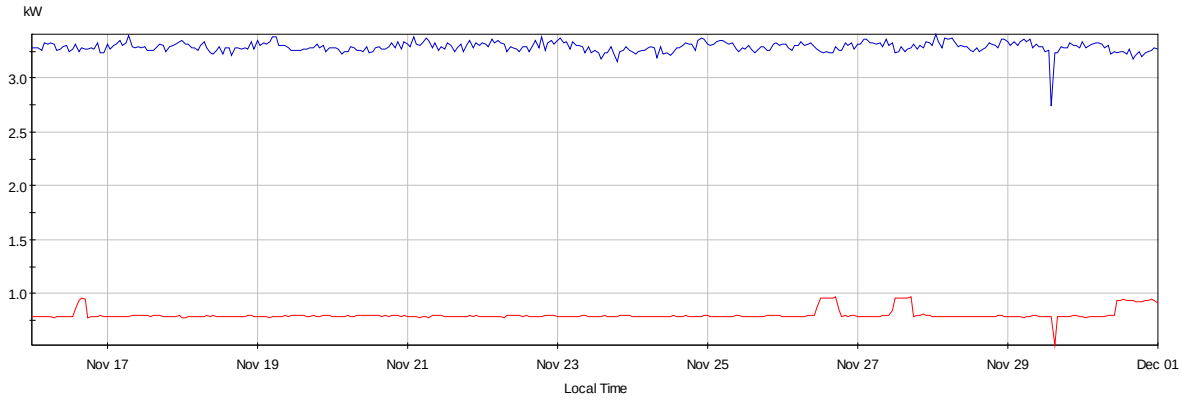
Source: DNV KEMA analysis

EEM2: Fan VFDs, motors and controls (Main Jail)

Preretrofit data and analysis

A DNV KEMA field engineer visited the project's sites on November 15th, 2011 to monitor the fans prior to the VFD retrofit in order to establish an energy consumption baseline profile. Spot power measurements were taken for all eight fans and the initial motor efficiencies were recorded where nameplate data was still legible. At two of the eight fans (one 5 HP and one 7.5 HP), meters were installed to monitor power consumption. As expected these constant speed fans had relatively constant power draws throughout the two week monitoring period (Figure 8).

Figure 8: Preretrofit Time Series Power Draw for 7.5 HP Fan (Red) and 5 HP Fan (Blue)



Source: DNV KEMA analysis

Note that the 7.5 HP fan actually drew less power than the 5 HP fan which was consistent with spot power measurements. During the inspection, it was noted that there was significant slack in the 7.5 HP fan belt which likely contributed to the low power draw. Since the profile shows a steady power draw throughout the two weeks of monitoring, the baseline energy consumption for each of the eight fans was calculated by multiplying the spot power measurement of each fan by 8,760 hours. Total baseline energy consumption is calculated at 155,437 kWh for these fans (Table 6).

Table 6: Measured Fan Power, Nameplate Motor Efficiencies and Calculated Fan Energy Consumption Preretrofit

Fan Description	Spot Power (kW)	Motor Efficiency (%)	Energy Consumed
F14 Supply	3.21	88.5	28,093
F14 Exhaust	1.98	84.0	17,371
F16 supply	3.99	87.5	34,926
F16 exhaust	1.74	Not found	15,207
SF1 supply	2.00[10]	Not found	17,520
SF1 exhaust	1.07	Not found	9,373
SF2 supply	2.21	Not found	19,360
SF2 exhaust	1.55	Not found	13,587

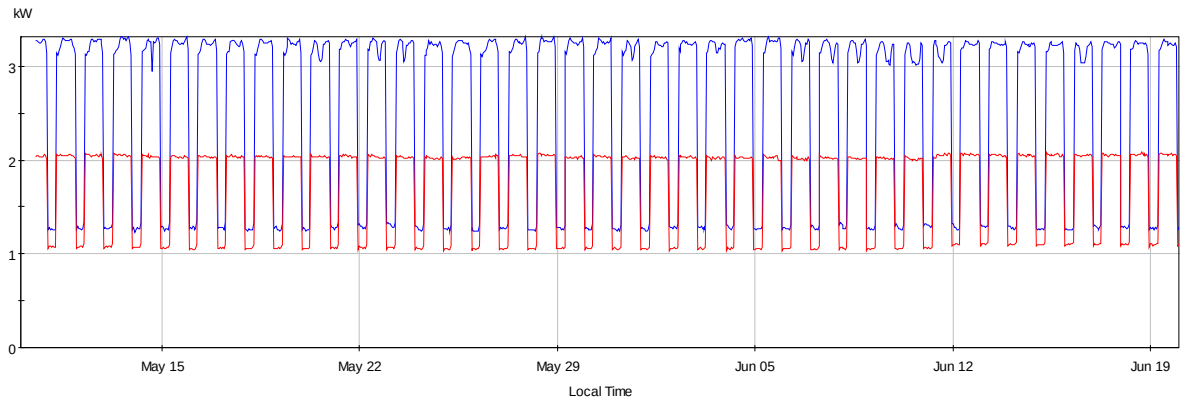
Source: DNV KEMA analysis

Postretrofit data and analysis

After the VFDs were installed at the fans, the DNV KEMA engineer returned to install power meters at the same two fans in order to see the effect of the new motor replacements and VFD controls. Fan motor efficiencies were also collected during that visit. The data shows that the VFDs turned down the speed of the fans for eight hours each night (Figure 9) resulting in power draws that were 38 percent (5 HP fan) and 52 percent (7.5 HP fan) of the maximum power draws during the day time. Using standard curves from the Electric Power Resource Institute (EPRI), this translated to a reduction in speed of about 66 percent and 78 percent of the maximum speed for the 5HP and 7.5 HP fans, respectively.

10 This is the 7.5 HP with belt slippage as shown in Figure 8. The actual spot measurement values were not used due to the issue with belt slippage. KEMA assumed at some point, the slippage would be discovered and fixed. The value that is used (2.0) comes from the measurement postretrofit when the fan is expected to be at 100 percent speed.

Figure 9: Post-retrofit Time Series Power Draw for 7.5 HP Fan (Red) and 5 HP Fan (Blue)



Source: DNV KEMA analysis

The average daily power draw profiles from Figure 9 were applied to the other fans which were not monitored and were grouped according to similarities in the fan horsepower ratings and zones served. Likewise, the reduction in power was assumed similar for each fan group. The power draw profile (which is in kWh/day) was multiplied by 365 to establish the postretrofit electric energy consumption of the fans. Total postretrofit energy consumption by the fans was calculated at 117,328 kWh. The exhaust fans were not monitored and were assumed to have a similar operation profile as their corresponding supply fans (for example, the profile for F14 supply will be similar to F14 exhaust/return).

Table 7: Calculated Fan Energy Consumption Post-retrofit

Fan Description	Motor Efficiency (%)	Energy Consumed
F14 Supply	89.5	21,973
F14 Exhaust	89.5	13,587
F16 supply	89.5	27,317
F16 exhaust	89.5	11,894
SF1 supply	91	14,655
SF1 exhaust	89.5	3,719
SF2 supply	91	16,193
SF2 exhaust	89.5	5,391

Source: DNV KEMA analysis

Gas energy savings analysis

It was not possible to perform both a pre and postretrofit gas consumption analysis for this site because there was not enough data in the postretrofit period. Therefore, DNV KEMA developed

an 8,760 spreadsheet analysis which analyzed the gas consumption of the heating system. The methodology uses the gas billing data as a sanity check. This methodology takes into account hourly changes in the outside air, building heating load, and the airflow rates to determine gas consumption:

$$Gas\ energy\ consumed = \frac{\sum 1.08 \times CFM \times \Delta T \times \%Load}{100{,}000 \times 0.8}$$

Where *Gas energy consumed* is the annual gas energy consumed in therms, *CFM* is airflow rate of the system, ΔT is the temperature differential between the outside air and heated air (95°F), *%Load* is an estimate on the loading needs of the building (modeled as a quadratic equation), *1.08* and *100,000* are conversion factors, and *0.8* is the assumed efficiency of the boiler.

In this equation %Load was used to calibrate the total therms energy consumed based on billing data. When the annual preretrofit values were calibrated to within 5 percent, the %Load parameter was left the same and the CFM was augmented on an hourly basis using values calculated from the postretrofit data (that is, 66 percent and 78 percent of the maximum speed for the 5HP and 7.5 HP fans during off hours as mentioned in the electric energy calculations above). In this way, available data from both pre and postretrofit periods can be incorporated into the algorithm for a more balanced and defensible energy savings claim.

Employing this method, the preretrofit gas energy consumption was 37,200 therms (compared to 2008/2009 billing data of 37,922 therms) using actual weather data for the corresponding time periods. When the values were normalized to average climate zone weather, the preretrofit gas energy consumption is 22,530 therms while the postretrofit gas energy consumption is 10,399 therms for a net savings of 12,131 therms.

EEM3: Packaged rooftop air conditioner replacement (Medium Security Jail)

Pre and postretrofit data and analysis

Only nameplate data of the RTU was collected during the pre and postretrofit site visits. No monitoring equipment was installed at the unit due to the small fraction of expected energy savings for this measure relative to the entire project. Using nameplate data in conjunction with the manufacturer's literature and the Preston Guide (used to determine the efficiency ratings of old units), the existing unit had an efficiency rating of 9.3 SEER which DNV KEMA reduced by 10 percent to account for degradation. The new unit had an efficiency rating of 17 SEER. Weather bins were used to estimate cooling load and was assumed to be linear. The following equation summarizes the calculation algorithm:

$$Savings = \%Load \times full\ load\ capacity \times hours \times \left(\eta_{existing} - \eta_{new}\right)$$

Where *Savings* is the energy savings of the new unit at that temperature bin relative to the existing unit, *%Load* is the estimated cooling load of maximum for each temperature bin (assumed as linear from 65°F to 90°F), η is the unit's efficiency in kW/ton converted from the SEER values of the new and existing rooftop air conditioner.

To account for economizer use, DNV KEMA assumed the unit was off at temperature bins below 70°F. Using this method, the preretrofit and postretrofit energy consumption were calculated at 1,962 kWh and 670 kWh, respectively, for an energy savings of 1,291 kWh.

EEM4 & EEM6: Fan VFDs, motors and controls (Medium Security Jail and Juvenile Hall)

Pre and postretrofit data and analysis

The pre and postretrofit data and analysis for EEM4 and EEM6 are exactly the same as EEM2 except that the measures were implemented at the Medium Security Jail and Juvenile Hall. For details of the methodology and analysis, please refer to EEM2 above. Here we will list the salient findings at these two other facilities.

Medium Security Jail (EEM4)

There are six sets of zonal fans that were scheduled to be retrofitted with high efficiency motors. Four of these sets were also scheduled for VFD retrofits. At the preretrofit site visit, spot power measurements were taken of the fans which ran at full speed. At three of the units (HV2 supply, HV1 supply, and HV6 supply), DNV KEMA installed meters to measure time-of-use. The result shows the fans operate for all hours of the day throughout the week.

At the postretrofit site visit, power meters were installed HV2 and HV6 with the expectation that at HV2 the fans will turn down at night and at HV6 the fan will shut off at night. DNV KEMA found that the HV2 fan actually shut off at night (as opposed to turning down at night), which was an unexpected finding. This loading scheme was kept for HV2 but for other fans which were expected to turn down instead of shut off, DNV KEMA reverted to the implementer's assumption of 60 percent speed during off hours (eight hours a day).

Data for the HV6 could not be retrieved due to logger failure but the schedule was assumed similar to HV2. Table 8 summarizes the values and results used in the electric energy savings calculation for EEM4.

Table 8: Measured Fan Power, Nameplate Motor Efficiencies and Calculated Fan Energy Consumption for EEM4

Fan Description	Preretrofit Spot Power (kW)	Preretrofit Motor Efficiency (%)	Preretrofit Hours	Preretrofit Energy (kWh)	Post-retrofit Motor Efficiency	Post-retrofit Hours	Postretrofit Energy (kWh)	Savings (kWh)
HV2 Supply	1.87	86.5	8,760	16,381	89.5	5,840	10,555	5,826
HV2 Return	0.48	82.5	8,760	4,187	85.5	5,840	2,694	1,493
HV1 Supply	1.88	86.5	8,760	16,478	89.5	8,760	12,315	4,162
HV1 Return	0.35	82.5	8,760	3,101	85.5	8,760	2,314	787
HV5 Supply	3.21	84.5	8,760	28,102	89.5	8,760	20,518	7,583
HV5 Return	0.86	84.0	8,760	7,551	85.5	8,760	5,737	1,814
HV4 Supply	2.14	85.5	8,760	18,720	89.5	5,840	11,922	6,798
HV4 Return	0.49	82.5	8,760	4,249	85.5	5,840	2,733	1,515

Fan Description	Preretrofit Spot Power (kW)	Preretrofit Motor Efficiency (%)	Preretrofit Hours	Preretrofit Energy (kWh)	Post-retrofit Motor Efficiency	Post-retrofit Hours	Postretrofit Energy (kWh)	Savings (kWh)
HV3 Supply	1.27	84.0	8,760	11,125	89.5	8,760	8,074	3,050
HV3 Return	0.38	82.5	8,760	3,320	85.5	8,760	2,477	842
HV6 Supply	1.44	85.5	8,760	12,649	89.5	5,840	8,056	4,593
HV6 Return	0.60	82.5	8,760	5,230	85.5	5,840	3,364	1,866

Source: DNV KEMA analysis

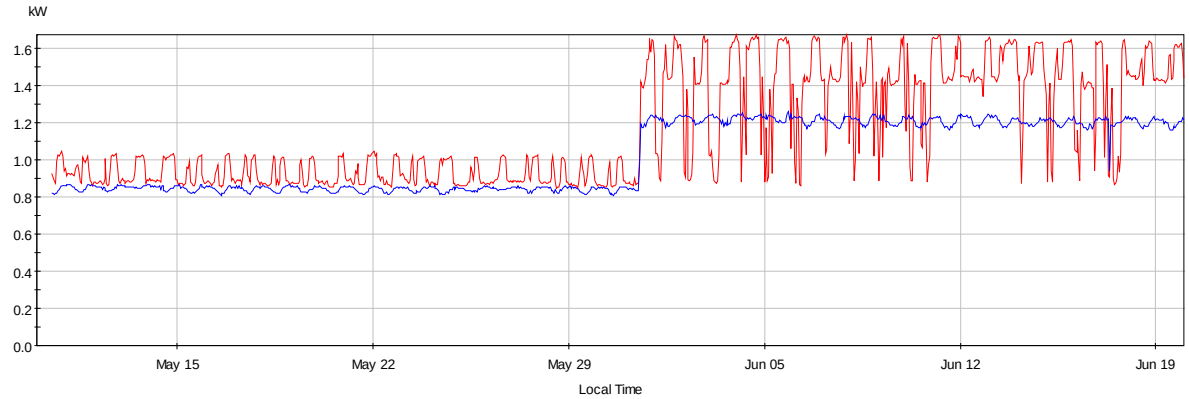
The gas energy savings calculation methodology is identical to EEM2 except the load profile was calibrated to this specific building's gas energy bills. Normalized to climate zone data, the pre and postretrofit gas energy use 17,488 and 13,550 therms, respectively, for an energy savings of 3,938 therms.

Juvenile Hall (EEM6)

At Juvenile Hall, there are 4 zonal fans that were scheduled to be retrofitted with high efficiency motors and VFDs. At the preretrofit site visit, spot power measurements were taken of the fans which ran at full speed. The units were assumed to run 8,760 hours a year.

At the postretrofit site visit, power meters were installed SF1 and SF2 to see how the fans operate with the new VFDs. Very minor hourly modulation is seen for both fans on a daily basis when the data is viewed for May or June (±10 percent). However, the transition from May to June shows the power increased by almost 50 percent for each fan (Figure 10).

Figure 10: Postretrofit Time Series Power Draw for HVAC1 (red) and HVAC2 (blue), Both 7.5 HP Fans



Source: DNV KEMA analysis

This is still a very low power draw since the two fans drew only about 0.8 to 1.05 kW each (versus preretrofit power draws of 0.99 and 3.05 kW). It is unclear whether the jump in fan power from May to June is due to seasonal differences or whether the jump is due to manual

resetting of the fans because of comfort issues. For the calculations, DNV KEMA took the average of both months to estimate the daily power draw profile. Table 9 summarizes the values and results used in the electric energy savings calculation for EEM6.

Table 9: Measured Fan Power, Nameplate Motor Efficiencies and Calculated Fan Energy Consumption for EEM6

Preretrofit Spot Power (kW)	Preretrofit Motor Efficiency (%)	Preretrofit Hours	Preretrofit Energy (kWh)	Postretrofit Motor Efficiency	Postretrofit Hours	Postretrofit Energy (kWh)
3.05	88.5	8,760	26,744	91.0	8,760	9,92
0.61	84.0	8,760	5,349	86.5	8,760	1,98
0.99	88.5	8,760	8,637	91.0	8,760	8,73
No return fan	NA	NA	0.0	86.5 (return fan added)	8,760	1,74
1.60	88.5	8,760	14,051	89.5	8,760	5,21
2.90	Not legible	8,760	25,395	89.5	8,760	9,42

Source: DNV KEMA analysis

The gas energy savings calculation methodology is identical to EEM2 except the load profile was calibrated to this specific building's gas energy bills. Normalized to climate zone data, the pre and postretrofit gas energy use 11,545 and 6,878 therms, respectively, for an energy savings of 4,668 therms.

EEM7 – VFD on supply and return fans (1400 Emeline)

Preretrofit data and analysis

A DNV KEMA field engineer visited the project's sites on November 15th, 2011 to monitor the fan power prior to the VFD retrofit in order to establish a baseline energy profile for the fans in question. Only one fan motor was monitored out of six since the fan operation was expected to be similar for all fans. For the other five fans, a spot power measurement was collected to establish a baseline power draw. The following is the data collected for the preretrofit visit.

Table 10: Fan Power Measurements Preretrofit

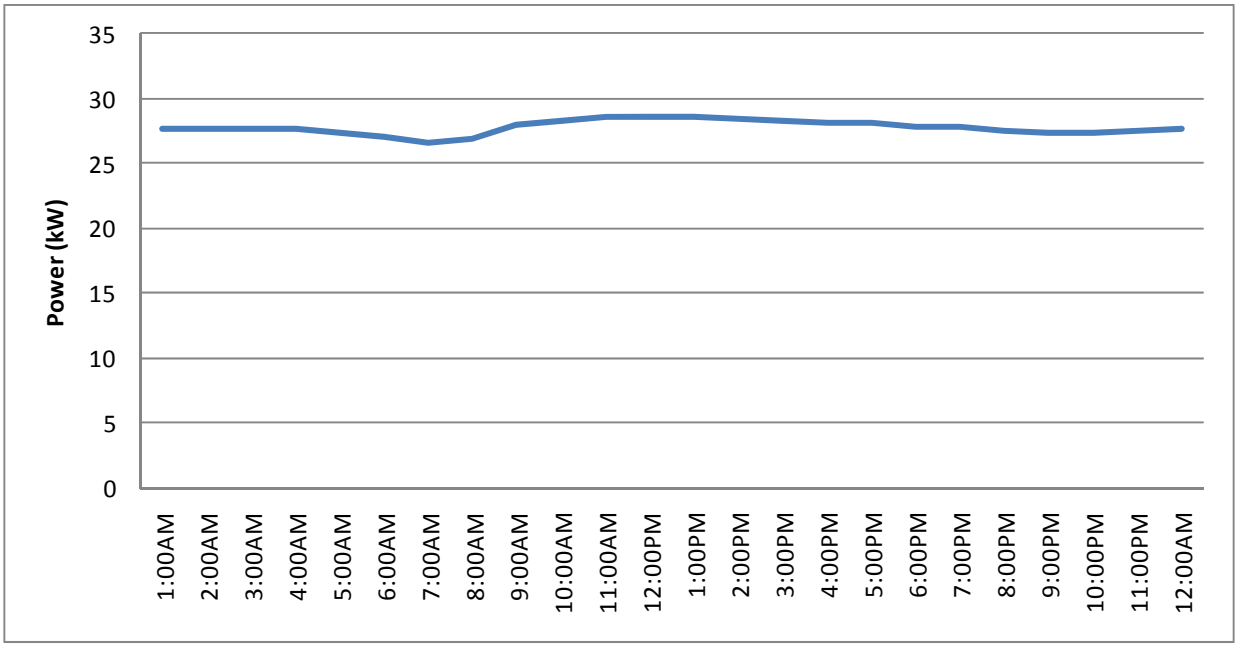
Fan Description	Spot Power (kW)	Metered (Yes/No)
Unit #1, Supply; 40 HP	27.9	Yes, two weeks
Unit #1, Return; 15 HP	Not on	No
Unit #2, Supply; 30 HP	21.0	No
Unit #2, Return; 10 HP	4.5	No
Unit #3, Supply; 25 HP	11.0	No

Fan Description	Spot Power (kW)	Metered (Yes/No)
Unit #3, Return; 7.5 HP	6.0	No

Source: DNV KEMA analysis

The data collected on the 40 horsepower fan showed constant speed operation seven days a week with an average power draw of 27.7 kW ± 1 kW. There was minimal modulation seen in the data (Figure 11) and there were no differences in weekday or weekend operation.

Figure 11: Typical Daily Power Draw of the 40 HP Fan on Inlet Vane Modulation Control



Source: DNV KEMA analysis

Using the data above, energy consumption was estimated as power draw multiplied by hours of operation. For the 40 horsepower supply fan, the hours of operation were assumed to be 8,760 since the data shows that the fan operates continuously throughout the week. The finding that this fan operates continuously was unexpected. DNV KEMA was expecting 14 hours of operation per day or 3,640 hours per year for all fans.

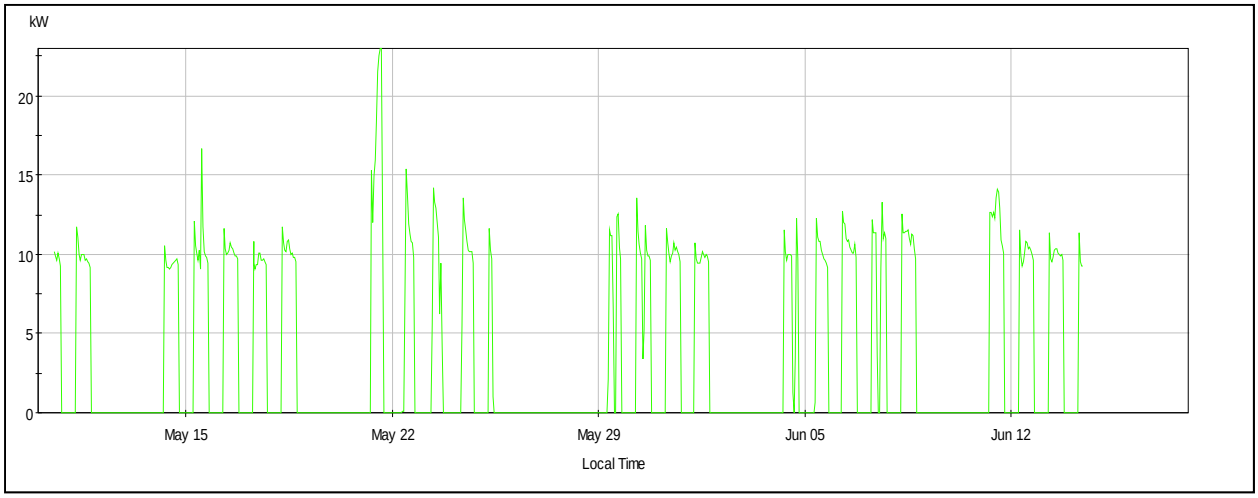
For the other five fans, DNV KEMA used the more conservative 3,640 hours per year since no metered data was gathered for those fans, although it is possible that these fans may also operate at 8,760 hours a year. A look at the billing utility data however shows that if indeed all fans operated continuously the total fan power would represent 82 percent of the building's overall electric energy. While it is not impossible, it is highly unlikely; hence, the more conservative hours of use were applied to the other five fans. The result was a baseline energy consumption of 436,574 kWh or about 50 percent of the total electric energy for this building. While this percentage was still on the high side for a large office building, it is difficult to argue

for a lower baseline due to the large electric demand of the fans measured at the site and established minimum hours of operation for the building. Hence, DNV KEMA asserts that although the building fan power as a percentage of total building energy is high, it is correct for this specific building.

Postretrofit data and analysis

After the VFDs were installed at all the fans and the fans were commissioned and operating normally, DNV KEMA returned to install a power logger at the same 40 HP fan to measure energy consumption.

Figure 12: Time Series Power Draw of 40 HP Fan over 5 Weeks After VFDs Were Installed

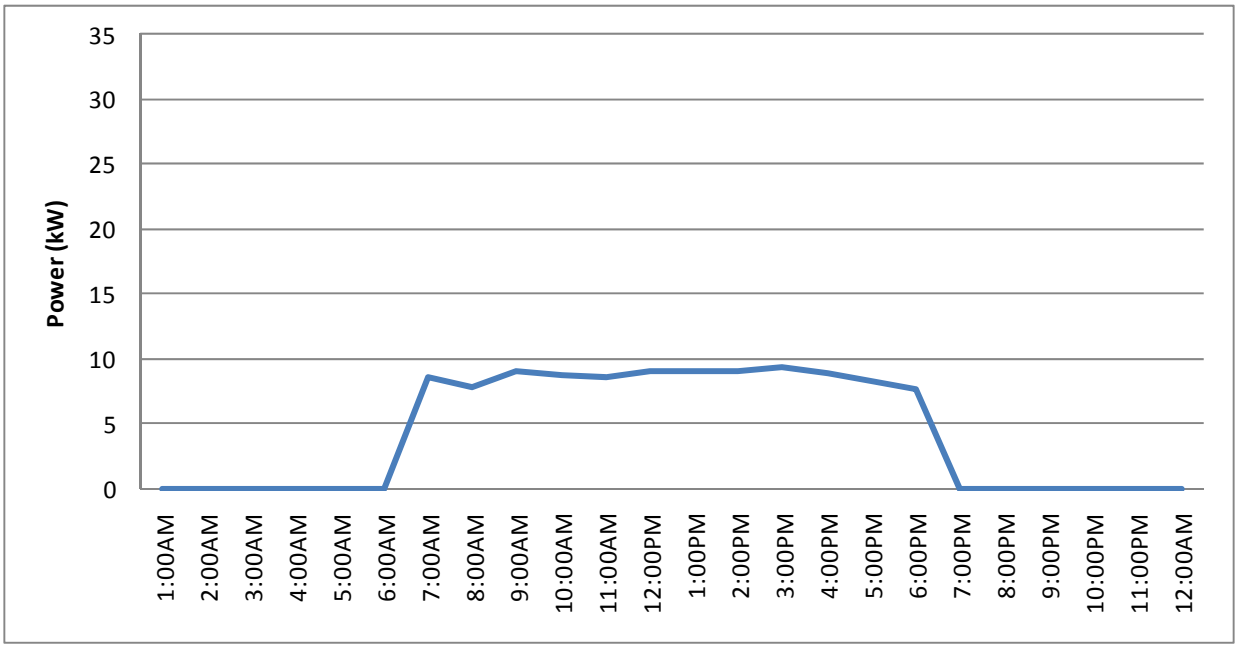


Source: DNV KEMA analysis

The figure above is a time series graph over the five-week interval. The graph shows VFD modulations on some days but were difficult to predict since the power draw of the fans could not be correlated to weather data (for example, there was an increase in fan power on May 21 but the weather conditions were not appreciably hotter during that time). However, with the exception of one or two days out of the five weeks, the fan power is fairly steady.

The data was processed into typical weekday and weekend day hourly profiles. The weekend power draw profile showed no operation while the weekday power draw showed operation from 6 a.m. to 6 p.m. This new schedule was an improvement to the presumed 6 a.m. to 8 p.m. operation in the baseline case. Comparing Figure 13 and Figure 11, it is obvious that the new VFD controls are savings significant demand and energy for this building for all hours and all days of the week.

Figure 13: Average Weekday Power Draw of 40 HP Fan with VFD



Source: DNV KEMA analysis

To estimate the total annual fan energy consumed postretrofit, the average fan power draw during the times the fan was on was multiplied by 3,120 hours (6 a.m. to 6 p.m. operation five days per week). This can be done because the fan data did not show a great deal of variability and can be approximated as running at one reduced speed. To estimate the fan energy for the other five fans that were not monitored, DNV KEMA assumed the power draw reduction were similar to the 40 HP fan. That is, the power draw in the postretrofit case was reduced to 31 percent of the preretrofit spot power reading. The new reduced hours of operation were applied to calculate the postretrofit energy consumption. Below is a table showing the final values used to evaluate the energy savings for this measure.

Table 11: Fan Power Calculation Values and Sources

Fan Description	Preretrofit Power Draw (kW)	Preretrofit Hours of Operation	Source	Postretrofit Power Draw (kW)	Postretrofit Hours of Operation	Source
Unit #1, Supply; 40 HP	27.9	8,760	Power and hours from monitored data	8.71	3,120	Power and hours from monitored data
Unit #1, Return; 15 HP	10.7	3,640	Power extrapolated from supply fan unit #1, hours assumed similar to building operation hours	3.34	3,120	Uses 31% of preretrofit power (similar to Unit #1 supply fan), hours assumed similar to Unit #1 Supply fan-monitored data
Unit #2, Supply; 30 HP	21.0	3,640	Spot power measured; hours assumed similar to building operation	6.55	3,120	Same as above
Unit #2, Return; 10 HP	4.5	3,640	Same as above	1.41	3,120	Same as above
Unit #3, Supply; 25 HP	11.0	3,640	Same as above	3.43	3,120	Same as above
Unit #3, Return; 7.5 HP	6.0	3,640	Same as above	1.88	3,120	Same as above

Source: DNV KEMA analysis

EEM8 – Chiller replacement (1040 Emeline)

Preretrofit data and analysis

Only nameplate data was collected for the existing chiller since chiller activity was expected to be minimal during the winter season and therefore would not yield useful data. DNV KEMA planned on using the nameplate data to look up the chiller efficiency, however, the chiller was very old and literature on that specific chiller could not be found. Instead, a chiller COP value of 3.4 was assumed which is the minimum efficiency based on 1978 Title 24 standards expected to be in place when the chiller was installed. The efficiency was de-rated by 10 percent to account for degradation. The baseline efficiency used in the calculations was 1.14 kW/ton as a result of these assumptions.

The analysis was similar to the postretrofit case (described below). Building/chiller loads and hours of operation were assumed to be the same; the only exception in the values used for the analysis is the chiller efficiency.

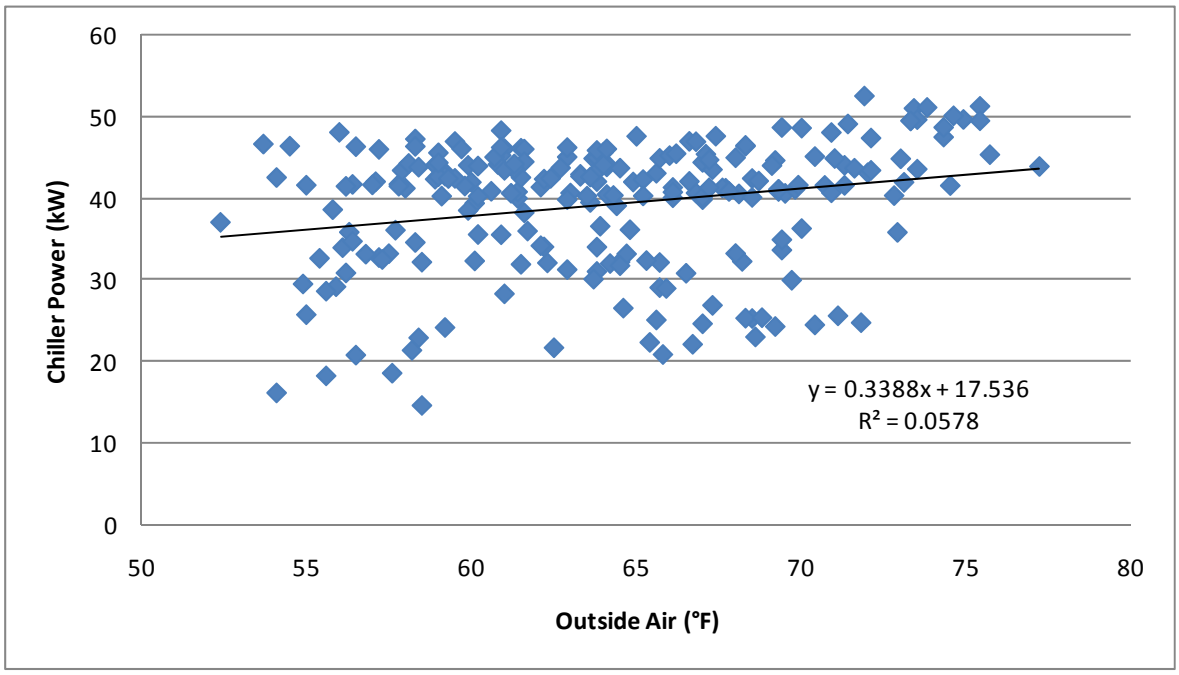
Postretrofit data and analysis

After the new chiller was installed and commissioned, DNV KEMA returned to install a power logger that measured time series power draw for approximately five weeks from May 10 to

June 18. The data when viewed in a time series showed the chiller operates from 9 a.m. to 6 p.m. during the weekdays and was completely shut off at other times.

This information allowed DNV KEMA to determine how to calculate the temperature bins used in the analysis. An 8760 spreadsheet analysis was performed using a temperature binning technique. Only temperatures from hours corresponding to 9 a.m. to 6 p.m. during weekdays were used in the analysis. Next, building load was determined by performing a regression analysis using the power data with the outside air temperature (Figure 14). Note that the R^2 value was low and was likely due to mild temperatures for that time interval which kept the chiller operating at only about 60 percent of full load. A better R^2 value can be achieved if building loads varied at wider a range during the monitoring interval but this was beyond DNV KEMA's control.

Figure 14: Regression Analysis of Using Chiller Power and Outside Air Temperature



Source: DNV KEMA analysis

The regression analysis resulted in building loads that ranged from 48 percent to 64 percent of full chiller load at temperature bins from 52.5°F to 87.5°F (the maximum for this climate zone). The following equation was used to determine energy savings at each five degree temperature bins:

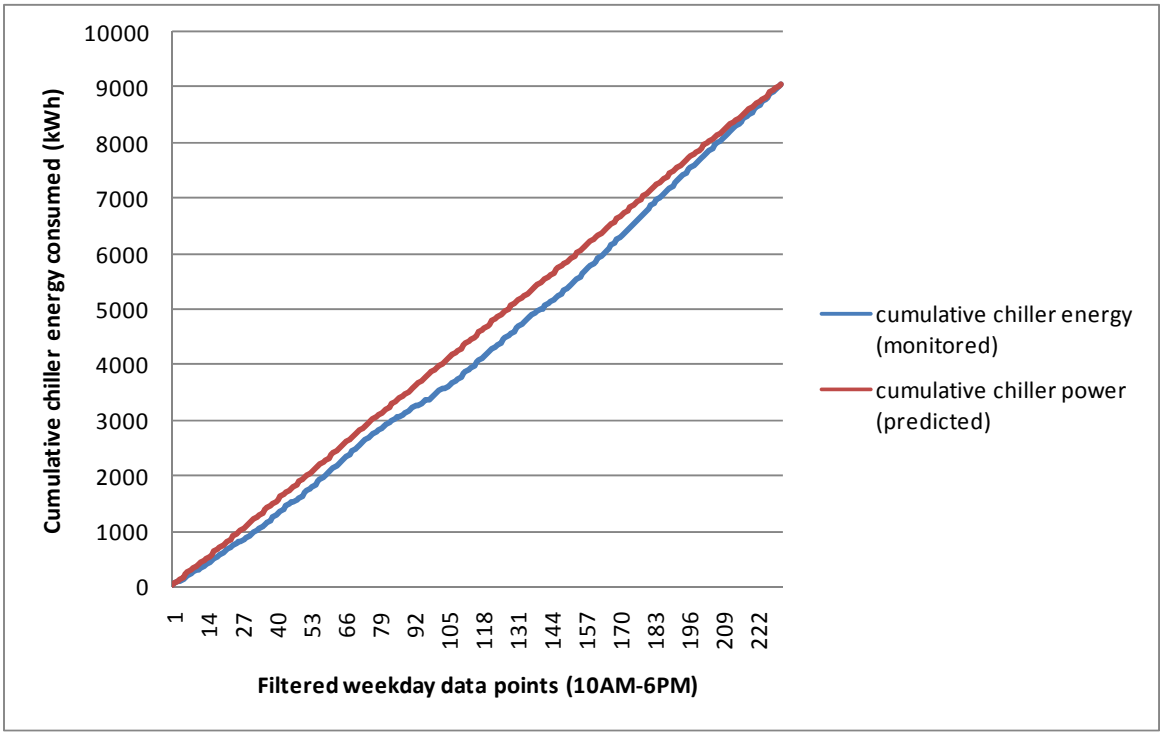
$$Savings = Percent\ Chiller\ Load \times full\ load\ caacity \times hours \times (\eta_{existing} - \eta_{new})$$

Where *Savings* is the energy savings of the new chiller at that temperature bin relative to the existing chiller, *Percent Chiller Load* is the estimated chiller load of maximum established using the regression analysis, η is the chiller efficiency for the new and existing chillers, *full load*

capacity is the rated capacity of the chiller and *hours* are the number of hours for that temperature bin.

Based on nameplate data, the rated efficiency of the new chiller was 0.673 kW/ton under standard conditions. Using this analysis, energy savings for the chiller replacement was estimated at 76,168 kWh. As mentioned above the R^2 value is poor. However, using this bin spreadsheet analysis, the cumulative energy consumption can still be reasonably predicted (Figure 15 below).

Figure 15: Cumulative Energy Consumed Over 5 Weeks Compared to Predicted Energy Consumed Using Bin Analysis (Weekend Days Removed)



Source: DNV KEMA analysis

Savings Results

Considering the implementation of all eight EEMs, this site saved 588,776 kWh of electric energy and 20,737 therms of gas energy.

Table 12 breaks down the ex post energy savings by measure. The ex ante energy savings are also provided for comparison.

Discussion

Ex post energy savings calculated for this project represent 158 percent (588,776 versus 373,749 kWh) of electric and 33 percent (20,737 versus 63,102) of natural gas savings when compared to

ex ante estimates. Below is a discussion for why ex post energy savings were either lower or higher than the ex ante claims (by measure).

EEM1: VFDs on hot water pumps (Main Jail)

Ex post energy savings for this measure is 67 percent of the ex ante estimate. The differences in energy savings are due to techniques used to estimate the pump energy consumption. The ex ante methodology relied on generalized assumptions of the pump while the ex post methodology used in situ power measurements to verify energy consumption. The discrepancy is simply due to the higher level of rigor employed in the ex post methodology.

Specifically, pump power draw (and consequently energy consumption) was estimated in the ex ante algorithm using standard assumptions for motor efficiency and the nameplate horsepower and did not represent actual operating conditions of the pump. When the pump power draw was measured, it showed a slightly lower power draw. In the ex ante algorithms, the preretrofit power draw was estimated at 3.87 kW while measured values during operation at preretrofit conditions showed the pump drew 3.01 kW. Hence, the baseline energy consumption in the ex post analysis showed less energy consumption and consequently less energy savings.

EEM2: Fan VFDs, motors and controls (Main Jail)

Ex post electric and gas energy savings for this measure are 64 percent and 26 percent of ex ante estimates, respectively. This is because the ex ante calculations were based on generalized assumptions and were meant to offer the recipients of the loan a ballpark estimate on what they can expect to achieve in terms of energy savings. The large differences in energy savings estimates are due to the rigor levels used in the calculation algorithms. DNV KEMA's methods offer a higher level of rigor for electric energy savings and a slightly improved rigor level for the gas energy savings and have corrected the spreadsheet errors seen in the ex ante analysis.

For this measure, there were two main factors that attributed to the lower electric energy realization rate. First, the assumptions used to estimate power draw of the fans did not match in situ power draws. Table 12 below shows fan power draw values used in the ex ante calculations for the preretrofit baseline case along with actual fan power measurements from that same time period. These higher ex ante power assumptions lead to higher estimations of savings potential.

Table 12: Ex Ante Assumptions on Fan Power Draw Versus In Site Measurements (Main Jail)

Fan Description	Ex Ante Estimate (kW)	Actual Spot Power (kW)	% Difference
F14 supply	4.32	3.21	74%
F14 return	2.95	1.98	67%
F16 supply	4.32	3.99	92%
F16 return	2.95	1.74	58%
SF1 supply	6.81	2.0	29%

Fan Description	Ex Ante Estimate (kW)	Actual Spot Power (kW)	% Difference
SF1 return	5.06	1.07	21%
SF2 supply	6.81	2.21	32%
SF2 return	5.06	1.55	30%
Total	38.28	17.74	46%

Source: DNV KEMA analysis

Secondly, there appears to be a number of errors in the spreadsheet that renders the results invalid. Notably, fan power draw of the SF1 and SF2 supply fans in the spreadsheet for the postretrofit case are entered as 2 and 3 horsepower when both should be 7.5. Additionally, the spreadsheet uses only the return fan power draws to calculate energy consumption for both return and supply fans when it should have used total fan power draw (return plus supply fans). The combination of these errors along with mismatches in measured versus assumed fan power draws account for the discrepancy in energy savings for this measure.

For gas energy, the ex ante analysis uses a degree hour technique based on average outside air temperature to estimate energy consumption (further explained in the "Ex Ante Savings" section above). The technique is low rigor because it relies solely on the implementer's assumptions. At best, it provides a very rough estimate of gas energy consumption.

The idea of the algorithm is that outside air needs to be heated to 70°F before it is delivered to the zones. However, this is an oversimplification and does not accurately predict actual energy consumption. In real systems, the delivered air is typically set at 95°F but is also augmented by various factors such as zonal temperatures, internal loads, infiltration, stratification, solar heat gain, and limitations inherent in the system. The delivered air will not always be the same temperature for all hours of the year. To see how the results of the ex ante analysis compares with actual conditions, the gas energy bills can be examined to see how far off the difference is. Results of the ex ante analysis predicts that the Main Jail uses 68,112 therms a year. Based on the documents found in the project file, for 2008/2009, the Main Jail used a total of 37,922 therms which also includes gas energy for cooking, laundry, and hot water use. The ex ante analysis overestimated energy consumption in the baseline case which led to greater savings estimates.

The ex ante analysis also underestimated energy consumption for the postretrofit conditions due to a spreadsheet error. To model night time setback, the implementer reduced the heating requirement from 70°F to 64°F. Ideally, it should be only applied to night time hours (from 8 p.m. to 6 a.m.) but the spreadsheet shows that this adjustment was applied to all hours. Coupled with the overestimate of baseline conditions, the ex ante analysis generally overstates gas energy savings for this measure and measure type (EEM4 and EEM6).

Consider that the ex ante (heating only) energy savings estimate for this facility was 46,216 therms but the gas bills for 2008/2009 shows the building used only 37,922 therms. It is not possible to save more energy than what is used.

Due to the difficulty in evaluating gas energy savings when adequate postretrofit billing data is not available, DNV KEMA used a method that is similar in rigor as the ex ante methodology but incorporates preretrofit billing data as a quality control check for the results. For this measure, when actual 2008/2009 weather data was inputted into the analysis, the preretrofit energy consumption predicted was in line with billed data (37,200 versus 37,922 therms). The errors in the night time setback adjustments (as seen in the ex ante analysis) were removed, and therefore, the results are more likely in line with reality. Note that the analysis can be fine-tuned if at least 12 months of postretrofit billing data is available, but due to the timeline for the evaluation of this project, was not incorporated.

EEM3: Packaged rooftop air conditioner replacement (Medium Security Jail)

Ex post energy savings is 46 percent of ex ante estimates. While there were differences in the parameters used in the energy savings calculation as well as structural differences in the methodology used, the main reason for the discrepancy in energy savings is due to the estimates on full load operating hours for the air-conditioning unit.

Because the facilities are located in a mild coastal climate zone, , the ex post methodology estimates that there is only about 456 full load hours when the compressor is required to turn on. This is in comparison to the 1,800 hours assumed in the ex ante algorithms. This equates to the compressor turning on for almost seven hours a day, five days a week throughout the year (for summer and winter seasons). In our experience, these units rarely cycle on except under hot conditions and even when they cycle on, seven hours a day at full load is higher than expected. Indeed, during both pre and postretrofit visits to the facility, the unit was observed to be off during the entire time when the engineer was on the rooftop installing loggers at other units. Furthermore, economizer energy savings was estimated using a hard value of 25 percent of the estimate on preretrofit energy consumption of the unit, which is subjective.

The binning methodology employed in the ex post analysis takes into account the mild weather conditions and uses a more realistic modeling of the effect on the economizer. Specifically, cooling load was modeled as a linear function versus outside temperature and the economizer was modeled as the unit turning off when outside air is 70°F or below rather than assuming a percent reduction as in the ex ante case. The ex post energy savings value claimed here represent a more conservative and realistic value given the mild weather conditions at the site.

EEM4: Fan VFDs, motors and controls (Medium Security Jail)

EEM4 is essentially the same as EEM2 except applied to the Medium Security Jail. The same issues found in EEM2 were present in the ex ante calculations for this measure as well, namely an over reliance on assumed power draw values and errors in the spreadsheet formula. Similar to EEM2, Table 13 below lists the ex ante analysis' assumed power draw values for all affected fans for this measure along with actual spot power measured by DNV KEMA.

Table 13: Ex Ante Assumptions on Fan Power Draw Versus In Site Measurements (Medium Security Jail)

Fan Description	Ex Ante Estimate (kW)	Actual Spot power (kW)	% Difference
HV1 Supply	4.32	1.88	44%
HV1 Return	0.98	0.35	36%
HV2 Supply	4.32	1.87	43%
HV2 Return	0.98	0.48	49%
HV3 Supply	1.82	1.27	70%
HV3 Return	0.76	0.39	50%
HV4 Supply	2.69	2.14	79%
HV4 Return	0.76	0.49	64%
HV5 supply	4.32	3.21	74%
HV5 return	1.42	0.86	61%
HV6 Supply	2.69	1.44	54%
HV6 Return	0.98	0.60	61%
Total	26.04	14.97	57%

Source: DNV KEMA analysis

While the total percent difference of fan power for this measure was similar to EEM2, EEM4 actually saved more energy in the ex post analysis instead of saving less due to the fact that the spreadsheet error used the return fan as the basis for total fan energy and coincidentally, for this system the return fan was significantly smaller than the supply fans. This had the effect of significantly underestimating baseline fan power. The correct approach, as mentioned in EEM2 above, should be to use total fan energy not just the return fan.

For gas energy, EEM4 has the same issues as EEM2 mentioned above which account for the large discrepancy in gas energy savings. Specifically, the error in applying the night time setback was also carried over to this measure along with the use of a low rigor methodology. These issues were corrected using the ex post analysis methodology which estimated baseline heating energy consumption at around 27,000 therms using 2008/2009 weather data. This is in comparison to an estimated range of 17,000 to 30,000 therms used for heating at this facility.[11]

EEM5: VFDs on hot water pumps (Juvenile Hall)

Ex post energy savings for this measure was 41 percent of the ex ante estimate. The lower energy savings were due to the same reasons as EEM1 mentioned above, but were also compounded by an error in the ex ante calculations. For this measure, one VFD is installed to

11 For this facility there is about 2000-3000 therms per month usage not related to heating that was estimated by looking at the summer months. This value was subtracted from the total annual gas usage to arrive at the gas energy usage range presented here.

control two separate but equally sized pumps which operate one at a time. The proper calculation methodology would to analyze the pump as though only one is on since the pumps alternate in function (one pump is on while the other is on standby). The ex ante calculations were performed such that both pumps are operating throughout the year which is not the case. The effect was a double counting of the energy savings for this measure; hence, the realization rate for this measure is very low.

EEM6: Fan VFDs, motors and controls (Juvenile Hall)

EEM6 was essentially the same measure as EEM2 but applied to the Juvenile Hall facility. However, the calculation errors found in EEM2 are not found in EEM6. Thus, for this measure, the lower ex post energy savings were only due to differences in measured power draw versus assumed power draw in the ex ante's analysis.

Table 14 below lists the ex ante analysis' assumed power draw values for all affected fans for this measure along with actual spot power measured by DNV KEMA.

Table 14: Ex Ante Assumptions on Fan Power Draw Versus In Situ Measurements (Juvenile Hall facility)

Fan Description	Ex Ante Estimate (kW)	Actual Spot power (kW)	% Difference
HV2 Supply	5.73	3.05	53%
HV2 Exhaust	1.27	0.61	48%
HV1	5.73	0.99	17%
HV3	3.87	1.60	41%
HV4	2.41	2.90	120%
Total	19.01	9.15	48%

Source: DNV KEMA analysis

In addition, DNV KEMA used five weeks of monitored power data to approximate the loading of the fans which did not correlate to the loading scheme assumed in the ex ante analysis. The ex post analysis estimated a lower energy consumption with the VFDs, but due to the already low baseline, there is not as much energy savings when compared to the ex ante estimates.

For gas energy, EEM6 used a similar algorithm as EEM2. Specifically, the analysis uses the same low rigor methodology to estimate gas consumption. To determine energy savings in the ex ante analysis, airflow was assumed to be reduced 20 percent during the day time and 50 percent at night. Fan power data measured for five weeks postretrofit at largest supply fan (7.5 HP) showed a reduction in power that is 38 percent of the original fan power draw. This translates to a reduction in flow to 65 percent of the original airflow rate (according to EPRI fan curves). DNV KEMA gave this measure the benefit of the doubt and assumed that the airflow rates for all fans decreased to 65 percent of the full airflow rate. This means that there was a 35 percent reduction in airflow rate for all hours as suggested by the data (Figure 10) rather than the 20

percent/50 percent reduction for daytime/nighttime split used in the ex ante analysis. The methodology and algorithms used to estimate energy consumption are also inherently different and likely contributed to the energy savings discrepancy.

Using the ex post analysis methodology, baseline heating energy consumption was estimated at around 18,600 therms using 2008/2009 weather data. This was in comparison to an estimated range of 16,000 to 25,600 therms used for heating for this facility.[12] The estimate at the lower range makes sense because there is an additional air handler unit for the administration zone which is not included in the calculations.

EEM7: VFD on supply and return fans (1400 Emeline)

Ex post energy savings for the VFD fans were 254 percent of ex ante estimates. This discrepancy is due largely to the higher rigor methodology employed in calculating the energy savings. In the ex ante analysis, the majority of the assumptions relied on the implementer's best guess which did not correlate to actual values when measured. For example, all motor fans including the largest fan (40 motor horsepower) were assumed to operate a majority of the time below the 80 percent fan loading mark which equated to a fan power draw of 20.9 kW or less for the 40 horsepower fan (based on the load curves provided by the implementers). However, as shown in Figure 11, the monitored data showed this fan draws consistently around 27.7 kW for all hours of the day during the two week monitoring interval and suggests that the baseline load is much higher. The implementer's methodology in general is sound absent additional data but relies heavily on estimates by the implementer which in this case did not reflect in situ operating conditions. There is a large error band when compared to actual conditions. The result was an underestimate of the baseline energy consumption and an overestimate of the postretrofit energy consumption which when combined understated the energy savings for this project. Additionally, for the 40 HP fan, annual hours of operation were estimated at 3,640 while the data suggests continuous operation. This pushed the realized energy savings higher since it affected the largest fan at the site.

DNV KEMA used both pre and postretrofit data in the form of spot power measurements (as opposed to using solely rated fan power) along with two weeks of preretrofit and five weeks of postretrofit data. This resulted in an energy savings estimates with a high level of rigor and reliability.

EEM8: Chiller replacement – Ex post energy savings were 306 percent of ex ante estimates. The reasons for this discrepancy were due to assumptions and calculation methodologies used in the analysis. The ex ante equations are highly generalized, with the only piece of information specific to this project being the chiller tonnage. Other than that, the efficiencies of the new and

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12 For this facility there is about 2200-3000 therms per month usage not related to heating that was estimated by looking at the summer months. This value was subtracted from the total annual gas usage to arrive at the gas energy usage range presented here.

existing chiller along with the estimated full load operating hours of the compressor were best guess estimates.

DNV KEMA used five weeks of chiller data to estimate the building load which aims at determining a parameter similar to the estimated full load operating hours (EFLH) of the compressor. This was determined to be twice (2057 versus 1000 hours) as much as the ex ante savings claim. In addition, the proposed chiller's rated efficiency was used in the analysis and will more adequately estimate energy consumption postretrofit. As shown in Figure 15, when the ex post algorithm was applied under similar outside air temperature conditions, it was able to closely predict the chiller energy consumption shown in the monitored dataset.

Ex Post Life-cycle Savings

Typically, energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

For the VFD measures (EEMs 1,2,4,5,6,7), only Baseline 1 is applicable since the VFDs can only be compared to the existing constant speed fans or pumps operating prior to the retrofit.

For EEM3, both Baseline 1 and Baseline 2 are considered. Baseline 1 is simply what the efficiency of the existing unit would be operating at if no replacement was implemented. DNV KEMA used the Preston's Guide and the old unit's model number to determine the SEER rating. In addition, the existing unit's SEER rating was reduced by 10 percent to account for degradation. A second baseline (Baseline 2) was also considered which took into account what current energy codes would require as the minimum efficiency standards (SEER 13 using 2008 Title 24 code) after RUL is reached. Although the unit was past its EUL, it was assigned one year of RUL as it was still operational at the time of replacement.

For EEM8, both Baseline 1 and Baseline 2 are considered. Baseline 1 is simply what the efficiency of the existing chiller would be operating at if no replacement was implemented. Because literature data was not available to determine this, DNV KEMA had to estimate this efficiency using an older version of Title 24 code and de-rating the equipment by 10 percent to account for degradation (1.14 kW/ton using 1978 Title 24 code minus 10 percent). A second baseline (Baseline 2) was also considered which took into account what current energy codes would require as the minimum efficiency standards (0.79 kW/ton using 2008 Title 24 code). Even though the chiller is past its EUL, a RUL of one year was used as the unit is still operational at the time of replacement.

Details of this calculation are shown below.

Table 15: Values Used in Life-cycle Savings Calculations by Measure

Measure	Early Replacement		Expected Replacement		EUL (years)	RUL (years)
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)		
EEM1 - Hot water pump VFDs (Main Jail)	13,316	0.0	13,316	0.0	15	N/A
EEM2 - Fan VFDs, motors, and controls (Main Jail)	38,109	12,131	38,109	12,131	15	N/A
EEM3 - Packaged rooftop air conditioner replacement (Medium Security Jail)	1,291	0.0	593	0.0	15	1
EEM4 - Fan VFDs, motors, and controls (Medium Security Jail)	40,333	3,938	40,333	3,938	15	N/A
EEM5 - Hot water pump VFDs (Juvenile Hall)	6,835	0.0	6,835	0.0	15	N/A
EEM6 - Fan VFDs, motors, and controls (Juvenile Hall)	52,578	4,668	52,578	4,668	15	N/A
EEM7-VFD retrofit	357,548	0.0	357,548	0.0	15	N/A
EEM8-Chiller replacement	76,168	0.0	34,201	0.0	20	1

Source: DNV KEMA analysis

When considering Baseline 1 over the entire life of the measure, this project yields an estimated energy savings of 9,212,484 kWh and 311,055 therms (Table 16). Under Baseline 2 (Table 17) the life-cycle savings is 8,405,338 kWh and 311,055 therms.

Table 16: Baseline 1 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	588,776	98.8	20,737
2	2012	588,776	98.8	20,737
3	2013	588,776	98.8	20,737
4	2014	588,776	98.8	20,737
5	2015	588,776	98.8	20,737
6	2016	588,776	98.8	20,737
7	2017	588,776	98.8	20,737

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
8	2018	588,776	98.8	20,737
9	2019	588,776	98.8	20,737
10	2020	588,776	98.8	20,737
11	2021	588,776	98.8	20,737
12	2022	588,776	98.8	20,737
13	2023	588,776	98.8	20,737
14	2024	588,776	98.8	20,737
15	2025	588,776	98.8	20,737
16	2026	76,168	32.7	0.0
17	2027	76,168	32.7	0.0
18	2028	76,168	32.7	0.0
19	2029	76,168	32.7	0.0
20	2030	76,168	32.7	0.0
Life-cycle	Total	9,212,480	1,646	311,055

Source: DNV KEMA analysis

Table 17: Baseline 2 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	588,776	98.8	20,737
2	2012	546,111	72.8	20,737
3	2013	546,111	72.8	20,737
4	2014	546,111	72.8	20,737
5	2015	546,111	72.8	20,737
6	2016	546,111	72.8	20,737
7	2017	546,111	72.8	20,737
8	2018	546,111	72.8	20,737
9	2019	546,111	72.8	20,737
10	2020	546,111	72.8	20,737
11	2021	546,111	72.8	20,737
12	2022	546,111	72.8	20,737
13	2023	546,111	72.8	20,737
14	2024	546,111	72.8	20,737
15	2025	546,111	72.8	20,737
16	2026	34,201	8.2	0.0
17	2027	34,201	8.2	0.0
18	2028	34,201	8.2	0.0
19	2029	34,201	8.2	0.0

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
20	2030	34,201	8.2	0.0
Life-cycle	Total	8,405,335	1,159	311,055

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Placer, County of (CBG-09-006)

Site Summary

Placer County conducted a wide ranging efficiency upgrade project involving 20 buildings distributed throughout the county. Affected buildings included the county courthouse, jail, Community Development Resource Center (CDRC), three libraries, a vehicle fleet building, and 13 office buildings housing various county operations. Table 18 below summaries the measures implemented throughout the county, the energy savings they were expected to generate before project implementation, and the evaluated energy savings.

Following the evaluation site visit, the site was able to complete additional measures and generate more savings because of their efficient use of grant funds. These additional savings are reflected in the total program savings, but are not included as part of the evaluation since the retrofits occurred after the site visit.[13]

Table 18: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1: Courthouse Central Plant Retrofit	94,127	27.5	-	112,149	15.6	-	119	N/A
EEM2: Courthouse Boiler Retrofit	-	-	2,016	22,429	-	2,762	N/A	137%
EEM3: Lighting Retrofits (18 buildings)	193,740	37.6	-	194,932	66.2	-	101%	N/A
EEM4: Lighting Occupancy Controls	5,150	-	-	1,016	0.4	-	20%	N/A
EEM5: Jail Packaged HVAC Retrofit (11x)	103,784	80.2	976	44,645	61.0	6,562	43%	672%
EEM6: Jail Boiler Retrofit	-	-	1,609	-	-	3,041	N/A	189%

13 Additional retrofits were included following the evaluation of this site. Two lighting projects and two boiler projects, with annual savings of 99,500 and 6,482 kWh, plus 2000 and 250 therms were completed subsequent to the evaluation. These savings are included as part of the total savings for this grant, but are not listed in this table, as they were not evaluated.

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM7: CDRC AHU Retrocomissioning	212,281	-	-	97,483	30.4	-	46%	N/A
EEM8: CDRC EMS boiler controls integration	27,345	-	1,699	1,991	-	928	7%	55%
EEM9: CDRC daylighting controls retrofit	10,235	-	-	1,033	2.6	-	10%	N/A
EEM10: Programmable Thermostats	20	-	17	45,401	-	2,269	227,006 %	13,347 %
EEM11: Vending Miser Controls	40,079	-	-	29,013	3.3	-	72%	N/A
Total	686,761	145.3	6,317	550,092	179.6	15,562	80%	246%

Source: DNV KEMA analysis

The lighting retrofit project was expanded, according to the updated information provided by the Energy Commission in December 2012. These savings are not reflected in the summary table Table 18 above, but are included as they were not evaluated. This report addresses the measures evaluated *only*.

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment is exceeded

Life-cycle savings for these EEMs were based on the appropriate DEER EUL values when available.

Table 19: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1	7,950,775 kWh	2,565 kW-Years	253,369 Therms
Baseline 2	5,626,664 kWh	1,557 kW-Years	115,695 Therms

Source: DNV KEMA analysis

Project Description

The project is subsequently described on a measure-by-measure basis.

EEM1: The county replaced an antiquated, 80-ton, dual reciprocating compressor chiller (Trane CGWC806RDNJJ432P) at the county courthouse with an 80-ton scroll compressor chiller (York YCWL0084HE). The county replaced the plant's chilled water and condenser water pumps and their associated motors. The cooling tower fan motor was also replaced. Variable speed drives were installed on the chilled water pump motors, condenser water pump motors, and the cooling tower fan motor. A water side economizer was also installed to provide free cooling during periods when the ambient temperature drops below 65 F.

EEM2: The space heating boiler at the courthouse was replaced with a 92 percent efficient boiler. The old boiler was well beyond its RUL. The pumping equipment (motors included) was also replaced and variable speed pump controls were implemented.

EEM3: The County completed comprehensive lighting retrofits in multiple buildings. Bulbs and ballasts were retrofit in three county libraries, a vehicle depot, the county courthouse, and 13 county office buildings. In most cases, either 32W T8 or 40W T12 fixtures were replaced with 28W T8 fixtures. In a few locations, incandescent and MH fixtures were replaced with either CFLs or more efficient MH fixtures. In total, 2,527 fixtures were affected by the project.

EEM4: The county planned to install 35 occupancy sensors across 4 buildings to control fluorescent fixtures.

EEM5 Twelve packaged HVAC systems serving the county jail were replaced. The previous units had been installed in the 1980s and were well beyond their EUL. The new units range in size from 5 tons to 12 tons. All units serve areas occupied by inmates and operate continuously.

EEM6: Three antiquated hot water boilers provided hot water for the county jail's kitchen equipment and make up air units. To reduce gas energy use, one of the three boilers was replaced with a new boiler and the control strategy was modified to prioritize utilization of the new boiler and sequence the pre-existing boilers as efficiently as possible.

EEM7: A retrocommissioning effort was undertaken at the Community Development Resource Center (CDRC) to better control the variable speed fans in four air handlers. In each of the facility's four air handlers, the pitot static pressure sensors were mounted incorrectly. As a result, the supply and exhaust fans in two of the units (AC1 and AC2) ran constantly at 100 percent speed. The supply and exhaust fans in AC3 modulated between limits of 100 percent and 58 percent, and the supply and exhaust fans in AC4 ran nearly constantly at 87 percent speed. By remounting the pitot static sensors in their proper orientations, proper control of fan speeds was re-established.

EEM8: The boilers at the CDRC were integrated in to the city's centralized Johnson Controls Metasys EMS system. Previously, only the hot water pumps were integrated into the central control system; on board boiler controls independently controlled boiler scheduling and hot water temperature reset. In addition to savings related to the controls modifications, this

measure was also intended to save energy through revised boiler scheduling for holiday and furlough day shutdowns.

EEM9: Daylighting controls were installed on 27 fixtures serving lobby areas of the CDRC building.

EEM10: Manual thermostats were replaced with programmable thermostats in five small government office buildings to better control HVAC scheduling.

EEM11: Vending Miser controls were installed on 18 refrigerated vending machines located throughout the County. These controls reduce energy consumption by shutting off vending machine lights and compressors when the areas adjacent to the machines remain unoccupied for extended periods.

Ex Ante Savings

The ex ante savings algorithms are discussed below on a measure-by-measure basis.

EEM1: The project scope assumed in the ex ante analysis differed from the scope ultimately implemented. Ex ante savings were calculated on the assumption that the compressors of the pre-existing chiller would be retrofit with Turbocor frictionless centrifugal compressors. Other plant upgrades accounted for in the ex ante analysis included a fan motor and drive retrofit for the cooling tower, a chilled water reset strategy, and DDC control implementation. Free cooling, chilled water and condenser water pump replacements, and pump VFD controls were not considered in the analysis.

Savings were calculated using a spreadsheet approach. For the chiller compressor retrofit measure, EFLH were determined based on a calculation that was not fully provided. Pre and postretrofit chiller Integrated Part Load Values (IPLV) were then applied to determine energy savings.

Savings for the chilled water reset measure were calculated based on assumed efficiency increases associated with resetting the chilled water temperature. The basis of these efficiency increase assumptions was not stated. Cooling tower fan savings were determined using a postretrofit fan operating speed profile of unknown origin. DDC control integration savings were determined by applying a percent savings scale factor to the cooling equipment's proposed annual energy usage.

Ultimately, these calculations were not relevant as the implemented scope was significantly different than the proposed scope.

EEM2: Boiler savings were estimated using a spreadsheet calculation based on the differing efficiencies of the pre-existing and installed boilers. The source of the boiler load estimate used in this calculation is unclear. The pre-existing boiler was estimated to be 72.3 percent efficient, while the installed boiler was assumed to be 85 percent efficient.

EEM3: The lighting savings spreadsheets used to arrive at project savings were not provided in their entirety. Therefore, a review of the ex ante lighting savings calculations could not be conducted.

EEM4: The lighting savings spreadsheets used to arrive at project savings were not provided in their entirety. Therefore, a review of the ex ante lighting controls savings calculations could not be conducted.

EEM5: An EFLH spreadsheet calculation was performed to estimate measure savings. The methodology used to determine ELFH was unclear. The provided documents suggest that some form of load calculation was performed, but the actual calculation was not provided for review. Savings were determined based on the annual load determined from the ELFH values and the efficiency delta of the units pre and postretrofit. Gas savings were determined using an identical approach.

EEM6: This measure was originally specified as a controls upgrade only. Prior to the retrofit, all three boilers operated in parallel, switching from high fire to low fire simultaneously based on load. Since the boilers are less efficient under low fire conditions, this strategy wasted energy.

The proposed strategy involved implementing lead/lag controls to stage the boilers sequentially. Savings were calculated based on a load profile specified for a typical day (source unknown). The differing efficiencies of the boilers operating under the two strategies to meet that load were then applied to determine savings.

The ex ante savings calculation did not account for the new boiler.

EEM7: The feasibility study does not provide a clear indication of the methodology used to estimate AHU static pressure sensor retrocomissioning savings at the CDRC.

EEM8: The savings calculations used to determine savings from upgrading boiler controls at the CDRC were not provided. The methodology used to estimate savings is unknown.

EEM9: Energy savings for the CDRC daylighting measure were determined by assuming a 25 percent reduction of lighting use during peak hours and a 20 percent reduction of lighting use during mid-peak hours. The calculations used to arrive at the estimated baseline usage were not provided.

EEM10: Almost no savings were claimed for the programmable thermostat measure (20 kWh, 17 therms). It is unclear if any calculations were actually performed to assess savings derived from this measure.

EEM11: The savings calculations related to this Vending Miser measure were not provided. Typically, deemed savings are applied for these measures, so a prescribed savings value was probably assigned to each machine and then multiplied by the quantity of affected vending machines.

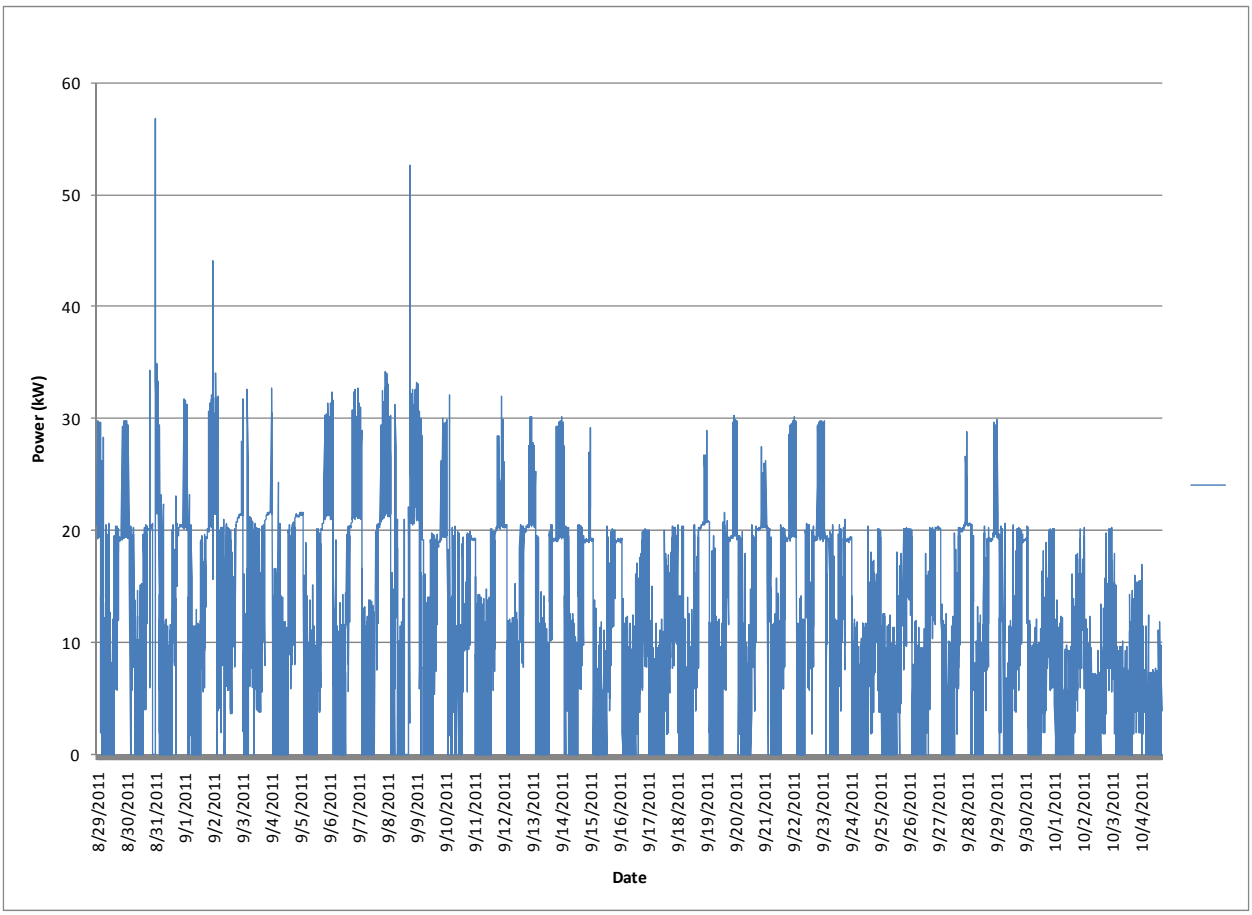
Project Evaluation

Because of the broad scope of this project, varying levels of rigor were applied to each EEM, with those responsible for the greatest and most uncertain savings given the most attention.

EEM1: The central plant retrofit conducted at the county courthouse was analyzed using bin methods. Metered data were collected during the pre-retrofit period to derive a load profile for

the courthouse. The pre-retrofit chiller was monitored with a true power logger for a 37 day period extending from the end of August 2011 through early October 2011.

Figure 16: CDRC Pre-existing Chiller Metered Data Profile

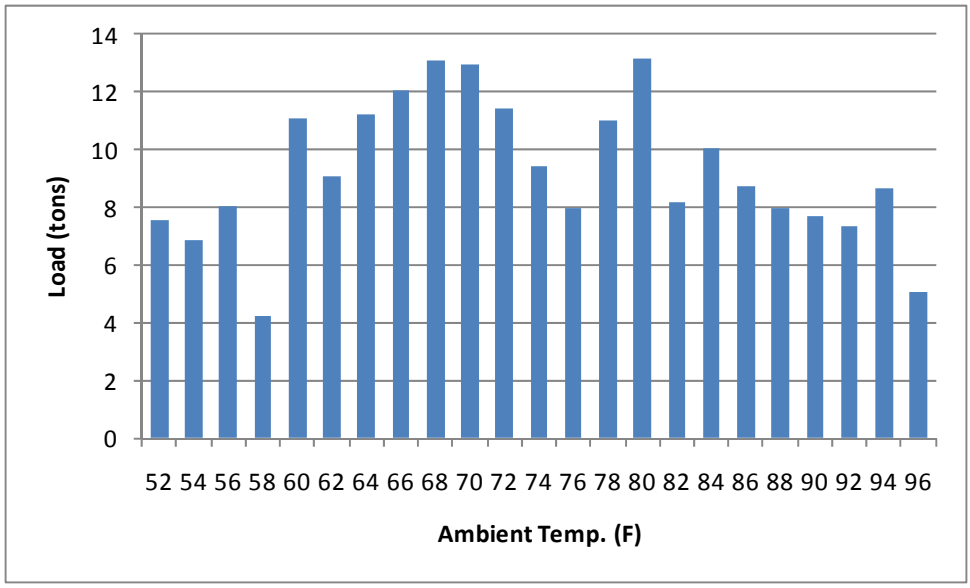


Source: DNV KEMA analysis

The metered data were translated into estimates of load as a function of ambient temperature using chiller performance data provided by the manufacturer and a part load curve appropriated from DOE 2 for reciprocating chillers. It was necessary to use a DOE 2 curve because it was not possible to obtain part load performance data for this chiller due to its age (the manufacturer could not provide it). The performance of the chiller at all loads was reduced by 10 percent to account for age related degradation.

Interestingly, the metered data set indicated that there was little to no correlation between ambient temperature and load. Figure 17 below, which shows the average load in each two-degree temperature bin used in the analysis, shows this lack of correlation. Also of note, the average load did not exceed 14 tons in any bin. In fact, the hourly load never exceeded 36 tons/h at any point during the metering period.

Figure 17: Chiller Load as a Function of Temperature



Source: DNV KEMA analysis

Pre-retrofit energy use was estimated using the loads determined for each temperature bin. Postretrofit energy use was determined based on the revised plant specifications (inclusive of the new chiller, chilled and condenser water pumps, cooling tower fan motor, VFDs, and water side economizer) and a controls sequencing schedule provided by controls contractor. Baseline 1 savings were taken as the difference between the pre-retrofit case annual energy use and the energy use projected for the new equipment. Peak demand savings were determined based on the average load observed during the metering period since there was no discernible load trend in the metered data.

Annual energy savings and peak demand savings were additionally determined relative to an expected replacement baseline consisting of a Title 24 compliant chiller, constant speed chilled and condenser water pumps operating with minimally compliant motors, and a constant speed cooling tower fan operating with a constant speed motor. The expected replacement baseline (Baseline 2) did not include water side economizing.

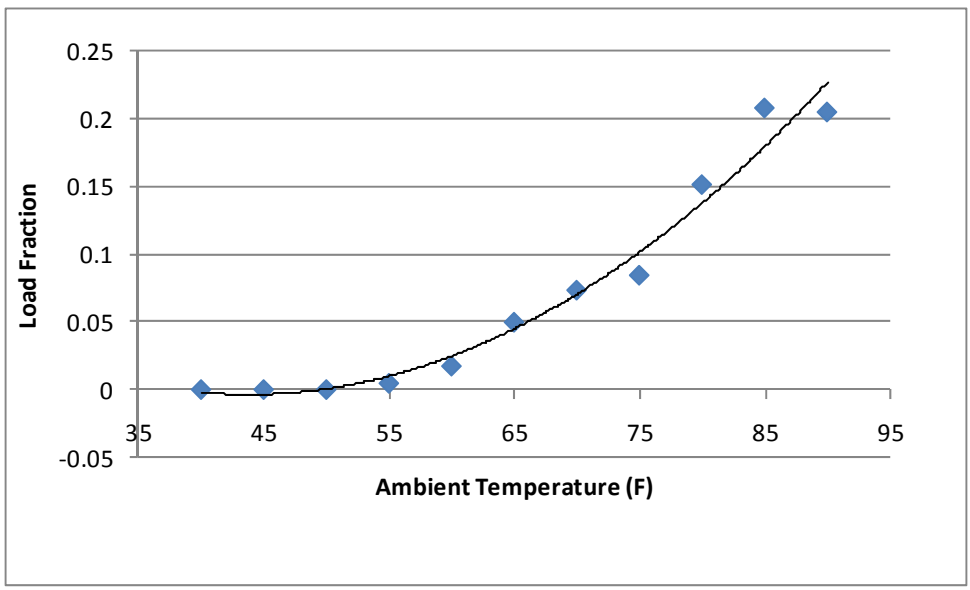
EEM2: Boiler savings were determined using gas billing data from the two years immediately preceding the retrofit (September 2009 through August 2011). Since the only major gas using equipment at the courthouse is the boiler, the billed therms effectively represent boiler gas consumption for each month. Using the two years of data, pre-retrofit annual gas usage during an average year was estimated as 11,711 therms. The pre-existing boiler's steam-to-water efficiency was estimated as 70.3 percent based on the feasibility study. For the feasibility study, boiler combustion efficiency was tested with a flue gas analyzer; boiler efficiency was then de-rated 5 percent to account for additional heat losses. The postretrofit boiler's steam to water

efficiency was estimated by reducing the manufacturer's claimed combustion efficiency (94 percent) by 2 percent to account for radiant and convective losses.

Gas savings were calculated as $Q_{saved} = Q_{billed-avg}\left(1 - \frac{n_{pre}}{n_{post}}\right)$, where the Q terms are in therms and the n terms represent boiler steam-to-water efficiencies. Expected replacement baseline savings were determined similarly; the pre-existing boiler efficiency was simply replaced by the efficiency of a Title 20 compliant boiler (80 percent).

Boiler pump savings were determined using a bin analysis based on a pump load diversity profile varying from 100 percent at 30 F to 50 percent at 65 F. According to the controls contractor, the new VFD controlled pumps operate at 65 percent speed whenever they are in use. By contrast, the pre-existing pumps operated at 100 percent speed during all operating hours. Savings for each 5-degree temperature bin were therefore determined by multiplying the delta in demand (kW) between the pre-existing and installed pumps by the load diversity factor and operating hours specific to a given bin. Savings from all bins were then summed to determine energy savings.

Figure 18: Packaged Unit Load Fraction as a Function of Temperature



Source: DNV KEMA analysis

Savings were determined based on the differing efficiencies of the installed units and the pre-existing units. Since the pre-existing units could not be observed, the pre-existing efficiencies were determined based on the Title 24 code efficiencies applicable at the time of unit installation (1982 T-24). These efficiencies were reduced by 10 percent to account for unit degradation, yielding final unit efficiencies of 6.75 EER.

To determine peak demand savings, it was first necessary to determine the ambient temperatures corresponding to the nine hours constituting the peak demand period. Those hours were then mapped to the temperature bins in the savings analysis, from which a time-weighted average was taken to determine the average demand reduction during the peak demand period.

Gas savings were similarly determined based on a bin analysis, albeit the load profile was not based on metered data. Instead, a linear load profile was assumed, with 0 percent load corresponding to 65 F and 100 percent load corresponding to 30 F. Savings were determined based on the differing efficiencies of the pre and postretrofit units. Pre-retrofit efficiencies were determined by de-rating the code efficiencies applicable at the time of installation by 10 percent, yielding 63.9 percent thermal efficiency.

Savings were also determined relative to an expected replacement baseline (Baseline 2). The analysis followed an identical process, but the pre-existing equipment efficiencies were replaced with minimally Title 24 compliant efficiencies. The appropriate efficiencies for this analysis were therefore 11 EER for cooling and 80 percent thermal efficiency for heating.

EEM6: The boiler retrofit completed at the jail kitchen entailed replacing one of the three pre-existing boilers with a new code-compliant boiler and altering the controls strategy of the three boilers. It was not possible to use billing data to assist in this analysis because the facility's gas bills include the gas use of another building, multiple packaged HVAC units on-site, and other gas equipment. Savings were therefore determined based on a load analysis of the equipment served by the boilers. The boiler plant serves three make up air (MUA) units ranging in capacity from 280,200 Btu/h to 700,000 Btuh/h, one flight dishwasher, and two 100 gallon steam kettles. Since the MUA units are 100 percent outside air and operate at constant speed whenever the kitchen is in use, the heat load for any hour was determined based on (1) the temperature difference between the ambient air and the kitchen temperature and (2) the supply air volume of the MUA units: $Q_{MUA} = 1.08 * CFM * (T_{amb} - T_{kitchen})$ (btu/h). The flight machine's heat load was determined based on the water requirements of the dishwashing process, the process temperatures required, and the operating schedule of the flight machine. Steam kettle energy requirements were similarly determined based on the heat requirements of the stews cooked in the kettles and the estimated heat loss rates from the kettle surfaces (as determined from the DOE approved 3E Plus software).

Loads from all end uses were then summed on an hourly basis to produce an 8,760 load profile for the steam kettles. The differing efficiencies and sequencing strategies of the installed and base case boilers were then applied to the loads to evaluate energy savings on an hourly basis. Figure 19 below summarizes the pre and postretrofit efficiencies used in the analysis. The pre-retrofit efficiencies were determined based on combustion testing conducted at the time of the feasibility study. Thermal efficiencies were determined at that time by de-rating the combustion efficiencies 3 percent to account for additional losses.

Figure 19: Jail Boiler Efficiencies

	Installed		Pre-retrofit	
	High Fire	Low Fire	High Fire	Low Fire
Boiler 1	80%	80%	73%	69%
Boiler 2	73%	69%	73%	69%
Boiler 3	73%	69%	73%	69%

Source: DNV KEMA analysis

The pre-existing case sequencing was specified such that all boilers operated in unison regardless of loads. Therefore, all three units would remain in low fire until the load was sufficient to kick all three units into high fire. By contrast, in the proposed scenario, the new boiler is always loaded first. Once the new boiler cannot meet the load, one of the two remaining boilers turns on in low fire, and then moves to high fire if required. If still more heat is required, the third boiler will first kick on in low fire, then switch to high fire only if needed. The appropriate operating logic and the efficiencies applicable to each firing mode in the pre and postretrofit scenarios were applied for all hours of the year. Annual savings were determined by summing the results determined for each hour.

Expected replacement baseline savings were determined by modifying the base case to include one new minimally code compliant boiler. The operating strategy in the expected replacement baseline was presumed to remain equivalent to the pre-retrofit operating strategy. Note that under this scenario, savings result entirely from the new controls sequences because the installed boiler was only minimally code compliant.

EEM7: Evaluating the efficacy of the air handler retrocommissioning project was predicated on determining whether the air handler fan VFDs now modulate beyond the limits previously imposed by the improperly mounted sensors. To accomplish this task, one of the site contacts provided 105 days (early January through early April) of VFD frequency data in 15 minute intervals from their EMS system for all eight fans affected by the project (four supply fans and four exhaust fans).

The data were first processed to identify correlation between ambient temperature and fan speed. If such a correlation existed, it would have been possible to extrapolate the data collected from the metered period to a yearlong postretrofit fan speed profile. However, after processing the data, it became apparent that there was little to no correlation between fan speed and ambient temperature. Rank correlation coefficients were calculated for each fan to verify that relationships between fan speed and ambient conditions did not exist. Table 20 below summarizes the results.

Table 20: Rank Correlations — CDRC Fan Speed and Temperature

Fan	Rank Correlation Coefficient
AC 1 - Supply Fan	0.01
AC 1 - Return Fan	0.04
AC 2 - Supply Fan	-0.21
AC 2 - Return Fan	-0.35
AC 3 - Supply Fan	0.13
AC 3 - Return Fan	-0.16
AC 4 - Supply Fan	-0.10
AC 4 - Return Fan	0.07

Source: DNV KEMA analysis

Rank correlation coefficients with an absolute value of less than 0.3 generally indicate that little to no relationship exists between two variables. In this case, the rank correlation coefficient exceeded 0.3 for only one of the fans. As such, the evaluation team concluded that significant relationships between fan speed and ambient temperature did not exist. Therefore, once savings were determined for the metering period, results were extrapolated on the basis of day type (weekday, weekend, or holiday) alone to a yearly profile to determine annual savings.

To determine savings for a given fan at a given time stamp in the meter data set, the metered fan speed was first used to estimate postretrofit power based on the fan laws. A conservative flow exponent of 2.5 was used in the standard affinity law equation $W_{fan} = kW_{full-load}\left(\frac{Hz_{observed}}{60}\right)^{2.5}$. Full load power, $kW_{full-load}$, was determined based on the fan motor size, and a full speed operating load factor of 80 percent. The pre-existing scenarios were then mocked up based on the limitations of the pre-existing cases. AC-1 and AC-2 fans were assumed to operate at 100 percent speed at all times. AC-3 fans were assumed to modulate in parallel with the postretrofit fans until the postretrofit fan speed reduced below 58 percent, at which point the pre-retrofit fans remained pegged at 58 percent. AC 4 fans were assumed to remain fixed at 87 percent speed at all times. The savings determined for each time stamp were then used to derive savings for weekday, weekend, and holiday day types for each fan to allow extrapolation to a full year savings profile.

EEM8: Integrating the CDRC boilers into the city's centralized Johnson Controls Metasys system did not save energy in and of itself. This retrocommissioning measure was expected to save energy because it also involved updating controls algorithms and placing the boilers and the associated hot water pumps on revised schedules. When boiler scheduling was discussed with the site contact, he indicated that the boiler schedules had not changed as a result of the retrofit. The operating strategies had however been changed. In the pre-retrofit state, the boilers operated with a fixed supply water temperature set point of 180 F and were staged such that the second boiler would turn on once the first boiler was 80 percent loaded. Under the revised control strategy, the boiler hot water temperature resets based on outside temperature. Below 55 F, the hot water temperature stays at 165 F; above 70 F, the boilers remain at the minimum

hot water temperature of 140 F. Boiler staging was altered slightly such that the second boiler will turn on if the first boiler is not able to meet the loop set point temperature within 20 minutes. In practice, this means that the second boiler will only turn on if the first boiler cannot meet the load while operating at peak capacity.

Savings for this measure were evaluated using a DEER prototype office building of post 2005 vintage in climate zone 11. The pre- and postretrofit control strategies and set points were mocked up in the building and the results were compared to determine electric and gas savings per square foot (kWh/sqft, therms/sqft). These values were then multiplied by the square footage of the CDRC building to estimate project savings.

EEM9: In the initial feasibility study report produced in 2009, this project was portrayed as a recalibration of daylighting controls distributed throughout the building. In reality, this project consisted of the installation of new daylighting controls in lobby area of the CDRC building. Ex post savings were calculated using the liberal assumption that the daylighting controls reduce daily lobby lighting operations by an average of eight hours per weekday. Savings were therefore calculated by multiplying the connected load affected by the new controls (kW) by the operating hour reduction of the controls. The peak demand savings were simply equivalent to the connected load reduction.

EEM10: Programmable thermostats were installed in five small office buildings (roughly 10,000 square feet each). These thermostats save energy through tighter set point control and reduced scheduling variability. Savings were estimated using the DEER prototype for small office buildings in Climate Zone 11 built prior to 1978. DEER runs output savings of 1.186 kWh/sqft and 5.927 kbtu/sqft for this measure. These values were applied to the total square footage affected by this project to estimate savings. Savings were only attributed to four of the five buildings because one of the buildings remains unoccupied and therefore does not require HVAC.

EEM11: Vending Miser control savings were estimated using a deemed savings approach. Deemed savings of 1,612 kWh per machine were estimated based on the Massachusetts Technical Reference Manual[14] and applied to all 18 affected machines.

Savings Results

The Placer County Project ultimately generated 550,092 kWh and 15,562 therms in energy savings and 179.6 kW in demand savings relative to Baseline 1. These savings correspond to realization rates of 80 percent and 246 percent for electric and gas respectively.

Relative to Baseline 2, the project saved 417,419 kWh and 6,554 therms, and reduced peak demand usage by 112.4 kW.

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14 Massachusetts Technical Reference Manual, http://www.ma-eeac.org/docs/MA%20TRM_2011%20PLAN%20VERSION.PDF.

Discussion

Since this project involved a wide range of measures, and the reasons for deviations from the ex ante estimates vary, the measures are discussed individually.

EEM1: The measure scope changed considerably for this project (see the ex ante discussion). Since the implemented measures were more extensive that those that were originally proposed, the annual energy savings increased. The decrease in peak demand savings is likely attributable to the fact that the analysis indicated little correlation between load and temperature. As such, the equipment is not fully loaded during the peak period, minimizing the opportunity for demand savings.

EEM2: The ex ante savings calculation used a postretrofit boiler efficiency that was less than the installed efficiency. Furthermore, the boiler load estimates used in the analyses also differed; billing data were used for the ex post analysis while the source of the load data for the ex ante analysis was unclear.

EEM3: The source of the minimal discrepancy between the ex ante and ex post lighting savings is not entirely clear because the complete ex ante calculations were not provided. Minor changes in fixture quantities resulting from evaluation verification work and adjustments to operating schedules are likely responsible for the small change in savings.

EEM4: The scope of the occupancy sensor portion of the lighting project changed significantly. The project scope originally included 35 occupancy sensors, while only six sensors were installed in practice. As such, the energy saved by this EEM decreased markedly.

EEM5: The evaluated savings relied on metered data to devise cooling load estimates, whereas the ex ante savings used an unknown approach. Since the ex post analysis revealed that the packaged unit loads were less than anticipated, the savings potential of the measure decreased substantially. Ex post gas savings greatly exceeded the ex ante estimate for two reasons. First, the evaluation utilized increased postinstallation unit efficiencies and reduced pre-retrofit unit efficiencies. Second, a different load profile was used in the evaluation analysis than in the ex ante analysis.

EEM6: The load profiles used in the ex post and ex ante calculations differed substantially. Since greater loads were determined based on the ex post analysis, the savings achieved by the measure increased.

EEM7: The calculations used to derive the ex ante estimate of AHU retrocommissioning savings were not provided. As such, it was not possible to assess why the savings estimates differed so substantially. In all likelihood, the ex ante analysis assumed that properly mounting the sensors would results in greater AHU speed reductions than were observed in practice.

EEM8: Again, the savings calculations that fed into the ex ante estimate were not provided for review. However, the fact that this measure did not save as much energy as originally projected is not surprising since the boiler and hot water pump operating schedules were not changed. Savings instead resulted from revised boiler staging strategies and hot water reset scheduling alone.

EEM9: The savings for this measure changed markedly because the measure scope changed. This measure was originally scoped as a retrocommissioning effort; daylighting sensors throughout the CDRC buildings were supposed to be recalibrated to reduce lighting usage. Instead, the measure involved implementation of daylighting controls on a small number of fixtures in the building's lobby. As a result, this measure yielded less energy savings than anticipated.

EEM10: Almost no savings were claimed for this project originally (20 kWh, 17 therms). Why such meager savings were claimed is unknown, but DEER model runs indicate that this measure should yield substantial energy savings.

EEM11: The original scope of this measure involved installing Vending Misers on 28 machines. In actuality, Vending Misers were installed on only 18 measures. Additionally, slightly different per-machine savings estimates were used ex ante and ex post. For the ex ante calculation, each Vending Miser was assumed to yield 1,431 kWh in energy savings (source unknown); the ex post calculation relied on a deemed savings value of 1,612 kWh per machine.

Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable. Table 21 below provides the annual energy savings estimates that fed into the life-cycle savings calculations, as well as the EULs for the installed measures.

Table 21: Values Used in Life-cycle Savings Calculations

Measure	Savings Relative to Pre-existing Equipment		Savings Relative to Standard Practice Equipment		EUL (years)	RUL (years)
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)		
EEM1: Courthouse Central Plant Retrofit	112,149	-	19,956	-	20	0
EEM2: Courthouse Boiler Retrofit	22,428	2,762	21,284	1,342	20	0

Measure	Savings Relative to Pre-existing Equipment		Savings Relative to Standard Practice Equipment		EUL (years)	RUL (years)
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)		
EEM3: Lighting Retrofits (18 buildings)	194,932	-	194,932	-	15	0
EEM4: Lighting Occupancy Controls	1,015		1,015		8	0
EEM5: Jail Packaged HVAC Retrofit (11x)	44,645	6,562	5,311	463	15	0
EEM6: Jail Boiler Retrofit	-	3,041	-	1,552	20	3
EEM7: CDRC AHU Retrocomissioning	97,483	-	97,483	-	10	0
EEM8: CDRC EMS boiler controls integration	1,991	928	1,991	928	15	0
EEM9: CDRC day lighting controls retrofit	1,033	-	1,033	-	8	0
EEM10: Programmable Thermostats	45,401	2,269	45,401	2,269	11	0
EEM11: Vending Miser Controls	29,013	-	29,013	-	5	0

Source: DNV KEMA analysis

Table 22 provides life-cycle savings for the project relative to Baseline 1.

Table 22: Life-cycle Savings Relative to Baseline 1

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	550,092	179.6	15,562
2	2012	550,092	179.6	15,562
3	2013	550,092	179.6	15,562
4	2014	550,092	179.6	15,562
5	2015	550,092	179.6	15,562
6	2016	521,078	176.3	15,562
7	2017	521,078	176.3	15,562
8	2018	521,078	176.3	15,562

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
9	2019	519,030	173.2	15,562
10	2020	519,030	173.2	15,562
11	2021	421,547	142.8	15,562
12	2022	376,146	142.8	13,293
13	2023	376,146	142.8	13,293
14	2024	376,146	142.8	13,293
15	2025	376,146	142.8	13,293
16	2026	134,578	15.6	5,803
17	2027	134,578	15.6	5,803
18	2028	134,578	15.6	5,803
19	2029	134,578	15.6	5,803
20	2030	134,578	15.6	5,803
21	2031	-	-	-
Life-cycle	Total	7,950,775 kWh	2,565 kW-Years	253,369 Therms

Source: DNV KEMA analysis

Table 23 provides life-cycle savings for the project relative to Baseline 2. Savings for the first year following the retrofit were calculated relative to the pre-existing equipment regardless of RUL. This approach was taken because the equipment would have presumably remained in place and operated for at least one year if the retrofit had not occurred.

Table 23: Life-cycle Savings Relative to Baseline 2

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	550,092	179.6	15,562
2	2012	417,419	112.4	8,043
3	2013	417,419	112.4	8,043
4	2014	417,419	112.4	6,554
5	2015	417,419	112.4	6,554
6	2016	388,406	109.0	6,554
7	2017	388,406	109.0	6,554
8	2018	388,406	109.0	6,554
9	2019	386,358	106.0	6,554
10	2020	386,358	106.0	6,554
11	2021	288,875	75.6	6,554
12	2022	243,473	75.6	4,285
13	2023	243,473	75.6	4,285
14	2024	243,473	75.6	4,285
15	2025	243,473	75.6	4,285
16	2026	41,239	2.1	2,895
17	2027	41,239	2.1	2,895
18	2028	41,239	2.1	2,895
19	2029	41,239	2.1	2,895
20	2030	41,239	2.1	2,895
21	2031	-	-	-
Life-cycle	Total	5,626,664 kWh	1,557 kW-Years	115,695 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

San Joaquin, County (CBG-09-010)

Site Summary

The County of San Joaquin applied for EECBG funds for 11 EEMs (EEMs) located within the census-designated place of French Camp, CA:

- Replacement of four rooftop packaged HVAC units serving the Juvenile Probation Camp
- Replacement of one kitchen make-up air unit at the Sheriff's Honor Farm kitchen
- Replacement of one package heat pump unit serving the Sheriff Building UPS room
- Replacement of two package heat pump serving the Sheriff Building radio communication tower room
- Replacement of one 550-ton water-cooled liquid chiller at the Jail Central Plant
- Installation of two new VFDs on two 150 horsepower (HP) pump motors serving the Jail Central Plant chilled water loop
- Installation of one new VFD on a 60 horsepower fan motor serving an air handling unit of the Sheriff Administration Building
- Installation of two new VFDs on two 50 HP pump motors serving the Jail Central Plant hot water loop
- Installation of one new VFD on a 50 HP fan motor serving an air handling unit of the Sheriff Administration Building
- Installation of one new VFD on a 30 HP cooling tower fan motor serving the Jail Central Plant chillers
- Installation of two new VFDs on two 25 HP fan motors serving two air handling units of the Sheriff Administration Building

DNV KEMA performed site visits at all French Camp facilities that received EECBG funded energy efficiency retrofits. During the site visits, DNV KEMA verified the quantity, manufacturers, and model numbers of the all the installed HVAC and VFD equipment. DNV KEMA also gathered HVAC operational schedules and set point temperatures for all the retrofitted systems.

Spreadsheet analysis was used to estimate energy savings for all measures using a combination of site findings and literature reviews. The analysis yielded an overall annual electric energy savings of 104 percent when compared to ex ante estimates. The energy and power savings by measure are provided in Table 24.

Table 24: Energy Savings Summary by Measure Category

Measure	Ex Ante			Ex Post Baseline 1			Realization Rate	
	Electric Energy (kWh)	Maximum Demand Reduction (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Maximum Demand Reduction (kW)	Gas Energy (Therms)	Electric	Gas
4-Ton Package HVAC Units	17,992	7.17	-	19,696	6.28	-	109.5%	-
Make-Up Air Unit	4,636	1.85	-	4,418	0.61	-	95.3%	-
3-Ton Package HP Unit	880	0.85	-	4,676	1.48	-	531.4%	-
5-Ton Package HP Units	3,846	1.06	-	6,059	4.64	-	157.5%	-
550-Ton Chiller Unit	293,309	295.50	-	293,309	295.50	-	100.0%	-
VFDs on 150 HP Motors	521,364	67.11	-	169,510	74.09	-	32.5%	-
VFD on 60 HP Motor	104,273	13.42	-	217,512	26.34	-	208.6%	-
VFDs on 50 HP Motors	173,788	11.19	-	402,343	49.82	-	231.5%	-
VFD on 50 HP Motor	86,894	22.37	-	181,261	21.95	-	208.6%	-
VFD on 30 HP Motor	52,136	6.71	-	31,197	13.63	-	59.8%	-
VFDs on 25 HP Motors	86,894	11.19	-	68,569	29.97	-	65.8%	-
Total	1,346,012	438.42	0	1,398,550	286.69	0	103.9%	N/A

Source: DNV KEMA analysis

Two EEMs that were initially planned under this grant, two 430 HP pump motor VFDs and 15 10-HP pump motor VFDs, were ultimately not pursued or financed through other funding sources. These measures have not been included in this evaluation report.

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses *minimally code-compliant* conditions or *standard practice* as the baseline once the RUL of the pre-existing equipment is exceeded.

The overall results from Table 24 yield a life-cycle energy savings of 22,444,801 kWh and life-cycle demand savings of 4,590 kW-years when considering Baseline 1 conditions. Using a dual

baseline defined as Baseline 2, the life-cycle savings total 21,742,914 kWh and 4,367 kW-years as shown in Table 25.

Table 25: Ex Post Life-cycle Savings Totals

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1	22,444,795	4,590	0
Baseline 2	21,742,917	4,367	0

Source: DNV KEMA analysis

Project Description

Measure 1: 4-Ton Package HVAC Units

This measure involved the replacement of four package HVAC rooftop units (RTUs) at the County Juvenile Probation Camp facility. The existing and replacement equipment is listed below:

- Location: Juvenile Probation Camp
  - Four 4-ton packaged RTUs
    - Existing units
      - Manufacturer: Carrier
      - Model Number: 48DJD007610
      - 4-ton cooling capacity, 9.0 SEER
      - 60 kBTU/hr heating capacity, 81 percent AFUE
    - Replacement units
      - Manufacturer: Trane
      - Model Number: YSC048E
      - 4-ton cooling capacity, 13 SEER
      - 60 kBTU/hr heating capacity, 80 percent AFUE

Measure 2: Make-up Air Unit

This measure involved the replacement of the kitchen make-up air unit at the Sheriff's Honor Farm kitchen. The existing and replacement equipment is listed below:

- Location: Sheriff's Honor Farm kitchen
  - One make-up air unit
    - Existing unit
      - Manufacturer: Unknown
      - Model Number: AH-162H
      - Flow rate capacity: 18,000 CFM
    - Replacement unit
      - Manufacturer: Greenheck

- Model Number: IGX-120-H32-H2
- Flow rate capacity: 14,000 CFM

Measure 3: 3-Ton Package Heat Pump Unit

This measure involved the replacement of one package HVAC RTU at the County Juvenile Probation Camp facility. The existing and replacement equipment is listed below:

- Location: Sheriff Building UPS room
  - One 3-ton packaged RTU15
    - Existing unit
      - Manufacturer: York
      - Model Number: D2CE036A25B
      - 3-ton cooling capacity, 9.2 SEER
    - Replacement unit
      - Manufacturer: Trane
      - Model Number: 4WCZ6036A3000B
      - 3-ton cooling capacity, 16.4 SEER

Measure 4: 5-Ton Package Heat Pump Units

This measure involved the replacement of four package HVAC RTUs at the County Juvenile Probation Camp facility. The existing and replacement equipment is listed below:

- Location: Sheriff Building radio communication tower room
  - Two 5-ton packaged heat pumps15
    - Existing units
      - Manufacturer: Lennox
      - Model Number: CHP-20-060-4G
      - 5-ton cooling capacity, 10.0 SEER
    - Replacement units
      - Manufacturer: Trane
      - Model Number: 4WCZ6060A4000B
      - 5-ton cooling capacity, 15.2 SEER

Measure 5: 550-Ton Chiller Unit

This measure involved the replacement of one of the two existing chiller units at the Jail Central Plant facility. The existing and replacement equipment is listed below:

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15 AFUE is not included as there is no heating load in this space. Unit cools electronics and operates in cooling mode year round.

- Location: Jail Central Plant
  - One 550-ton chiller
    - Existing unit
      - Manufacturer: York
      - Model Number: YT-K1-L1-E2-CSE
      - 550-ton cooling capacity, 0.565 kW/ton calculated non-standard part-load value (NPLV)
    - Replacement unit
      - Manufacturer: Trane
      - Model Number: CVHF058
      - 550-ton cooling capacity, 0.361 kW/ton calculated NPLV

EEMs 6 through 11 of this grant report involved of the replacement of non-functioning existing VFD with new VFD control units. The existing VFDs had reached the end of their useful life and were no longer functional. In this state, the VFD controls were bypassed, and the motors operated at constant speed. The retrofits replaced the non-functioning drives with new units, and reestablished VFD control of the pump and fan motors.

Measure 6: VFDs on 150 HP Motors

This measure involved the installation of two new VFD units serving the chilled water pump motors at the Jail Central Plant facility. The existing and replacement equipment is listed below:

- Location: Jail Central Plant
  - Two VFDs for 150 HP pump motors
    - Existing units
      - Manufacturer: ABB
      - Model Number: SAP1050MC40
    - Replacement units
      - Manufacturer: Square D
      - Model Number: ATV21HC11N4

Measure 7: VFD on 60 HP Motor

This measure involved the installation of one new VFD unit serving a 60 HP fan motor on an air handling unit of the Sheriff Administration Building. The existing and replacement equipment is listed below:

- Location: Sheriff Administrative Building
  - One VFD for 60 HP fan motors
    - Existing unit
      - Manufacturer: ABB
      - Model Number: ACH400
    - Replacement unit
      - Manufacturer: Square D

        - Model Number: ATV21HD45N4

Measure 8: VFDs on 50 HP Motors

This measure involved the installation of two new VFD units serving the hot water loop pump motors at the Jail Central Plant facility. The existing and replacement equipment is listed below:

- Location: Jail Central Plant
    - Two VFDs for 50 HP Pump Motors
        - Existing units
            - Manufacturer: ABB
            - Model Number: V07247
        - Replacement units
            - Manufacturer: Square D
            - Model Number: ATV21HD37N4

Measure 9: VFD of 50 HP Motor

This measure involved the installation of one new VFD unit serving a 50 HP fan motor on an air handling unit of the Sheriff Administration Building. The existing and replacement equipment is listed below:

- Location: Sheriff Administrative Building
    - One VFD for 50 HP Fan Motors
        - Existing unit
            - Manufacturer: ABB
            - Model Number: ACH401C04132
        - Replacement unit
            - Manufacturer: Square D
            - Model Number: ATV21HD37N4

Measure 10: VFD on 30 HP Motor

This measure involved the installation of one new VFD unit serving a 30 HP fan motor on a chiller cooling tower of the Jail Central Plant facility. The existing and replacement equipment is listed below:

- Location: Jail Central Plant
    - One VFD for 30 HP fan motors
        - Existing unit
            - Manufacturer: Unknown
            - Model Number: Unknown
        - Replacement unit
            - Manufacturer: Square D
            - Model Number: ATV21HD22N4

Measure 11: VFDs on 25 HP Motors

This measure involved the installation of two new VFDs unit serving 25 HP fan motors on air handling units in the Sheriff Administration Building. These existing and replacement equipment is listed below:

- Location: Sheriff Administrative Building
  - One VFD for 25 HP fan motors
    - Existing unit
      - Manufacturer: ABB
      - Model Number: SCH501-025-4-09P2
    - Replacement unit
      - Manufacturer: Square D
      - Model Number: ATV21HD18N4

Ex Ante Savings

Measures 1-4: Package Units

For EEMs one through four, the ex ante savings estimates utilized the Pacific Northwest National Laboratory's Rooftop Unit Comparison Calculator[16] (RTUCC) online energy calculator. This energy simulation calculator performs a bin analysis savings calculation based upon user input variables that include building location and type, set point temperatures, cooling capacity, SEER values, and economizer functionality. For all of these simulations the reference location input was Sacramento, CA and building type input was "office-medium." The calculator's primary output of interest is the annual energy consumption (kWh/ year) for the existing and retrofit equipment, from which annual energy savings can be easily calculated.

DNV KEMA calculated the ex ante electric demand savings for the measures one through four, as the ex ante documentation only provided annual savings. Demand savings was calculated by as the difference of electrical power at full-load cooling capacity between the high-efficiency replacement units and that of the existing units.

Measure 1: 4-Ton Package HVAC Units

The following inputs were utilized in the Measure 1 ex ante energy simulation calculation:

- Schedule: M-Fri, 7 a.m. to 5 p.m.
- Set point temperature: 73°F
- Cooling capacity per unit: 48 kbtu/h in 1 stage
- Retrofit unit: 15 SEER, economizer enabled

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16 http://www.pnnl.gov/uac/.

- Existing unit: 9 SEER, economizer disabled

The ex ante analysis yielded an annual energy savings estimate of 17,992 kWh for all four units. The DNV KEMA calculated ex ante demand reduction for this measure is 7.17 kW.

Measure 2: Make-up Air Unit

The following inputs were utilized in the Measure 2 ex ante energy simulation calculation:

- Schedule: M-Fri, 7 a.m. to 5 p.m.
- Set point temperature: 73°F
- Cooling capacity: 120 kbtu/h in 2 stages
- Retrofit unit: 15 SEER, economizer enabled
- Existing unit: 8 SEER, economizer enabled

The ex ante analysis yielded an annual energy savings estimate of 4,636 kWh. DNV KEMA calculated ex ante demand reduction for this measure is 1.85 kW.

Measure 3: 3-Ton Package Heat Pump Unit

The following inputs were utilized in the measure 3 ex ante energy simulation calculation:

- Schedule: M-Fri, 7 a.m. to 5 p.m.
- Set point temperature: 73°F
- Cooling capacity: 36 kbtu/h in 1 stage
- Retrofit unit: 14 SEER, economizer enabled
- Existing unit: 10 SEER, economizer disabled

The ex ante analysis yielded an annual energy savings estimate of 880 kWh. DNV KEMA calculated ex ante demand reduction for this measure is 0.85 kW.

Measure 4: 5-Ton Package Heat Pump Units

The following inputs were utilized in the measure 4 ex ante energy simulation calculation:

- Schedule: M-Fri, 7 a.m. to 5 p.m.
- Set point temperature: 73°F
- Cooling capacity: 60 kbtu/h in 1 stage
- Retrofit unit: 14 SEER, economizer enabled
- Existing unit: 10 SEER, economizer disabled

The ex ante analysis yielded an annual energy savings estimate of 3,846 kWh. DNV KEMA calculated ex ante demand reduction for this measure is 1.06 kW.

Measure 5: 550-Ton Chiller Unit

The ex ante energy savings analysis for the chiller unit involved a spreadsheet savings methodology that utilized three years of pre-retrofit billing data for the Jail, annual operating hours, plant pumping power requirements, and calculated NPLV to first isolate the pre-retrofit chiller load and then determine kWh savings resulting from the improvement in NPLV efficiency of the retrofit chiller over the existing chiller unit.

The method began by calculating average monthly kWh consumption using data from 2008 to 2010. To account for the Jail lighting and other energy consumption, an energy baseline was determined from the lowest monthly average kWh value—December in this case. This baseline energy value was then subtracted from each monthly average value to produce a calculated average cooling plant load for each month. The equation used to arrive at the monthly average cooling plant load was:

$$Avg\ Plant\ kWh_{month} = Avg\ Jail\ kWh_{month} - Avg\ Jail\ kWh_{lowest\ monthy\ avg}$$

Next, the annual energy consumption of the two chiller's pumps and the chilled water distribution pump was calculated using pre-retrofit annual operating hours, power capacities, and motor load factors. Using the annual energy consumption values for the pumps, the ratio of annual pumping energy consumption to annual total cooling plant energy consumption was calculated. This annual pumping energy to total energy consumption ratio was then applied to each individual month to arrive at a monthly average pumping energy consumption. The monthly average chiller load was then calculated by subtracting the monthly average pumping energy consumption from the monthly average total cooling plant load. The equation to arrive at the monthly average chiller load is as follows:

$$Avg\ Chiller\ kWh_{month} = Avg\ Plant\ kWh_{month} - Avg\ Plant\ kWh_{month} \times \frac{Annual\ Pump\ kWh}{Annual\ Plant\ kWh}$$

The average annual chiller load was then calculated as the sum of the monthly average chiller loads.

Next, the non-standard part load values (NPLV) for the existing and replacement chillers were calculated from the kW/ton efficiency performance at 100, 75, 50, and 25 percent chiller loads and the percentage of time the chiller is expected to run at each load value, which were provided by Trane, and the following NPLV equation:

$$NPLV = \frac{1}{\frac{0.01}{100\%\frac{kW}{ton}}} + \frac{1}{\frac{0.42}{75\%\frac{kW}{ton}}} + \frac{1}{\frac{0.45}{50\%\frac{kW}{ton}}} + \frac{1}{\frac{0.12}{25\%\frac{kW}{ton}}}$$

The NPLV for the existing chillers was calculated as 0.565 kW per ton while the NPLV for the replacement chiller was 0.361 kW per ton. With these two efficiency performance values, a percent change in NPLV was calculated using the following equation:

$$\text{NPLV } \%\Delta = 1 - \frac{\text{NPLV}_{\text{replacement}}}{\text{NPLV}_{\text{existing}}}$$

The annual energy savings for replacement of one of the two chillers was calculated by multiplying the average annual chiller load by the percent change in NPLV and the ratio of replaced chillers to total chillers (1/2 in this case to account for the replacement of one of the two chillers in use at the plant), as shown in the equation below:

$$Annual\ kWh\ Savings = Avge\ annual\ chiller\ kWh\ \times \mathrm{NPLV}\ \%\Delta \times \frac{1}{2}$$

Under this analysis method, this measure claimed an annual energy savings of 293,309 kWh.

The ex ante demand savings was calculated via the same methodology described for the annual energy savings calculation, except for the following changes:

- Monthly on-peak demand billing data substituting for the monthly energy consumption data
- All annual hours multipliers were left out of this method so that the calculations are manipulating power and not energy values.

Under this analysis method, this measure claimed a demand reduction of 295.50 kW.

Measures 6 through 11: VFDs

For EEMs six through eleven, ex ante savings were estimated to be a 30 percent savings from the existing annual energy usage. No savings documentation was provided by the Energy Commission or the site contact to support the savings values found in the tracking database provided to DNV KEMA. Using the ex ante 30 percent savings estimation, DNV KEMA calculated an ex ante demand reduction value for each measure based upon the motor power rating and the estimated 30 percent load reduction. The ex ante savings claims for measure six through eleven are presented below.

Measure 6: VFDs on 150 HP Motors

This measure claimed an annual energy savings of 521,364 kWh and DNV KEMA calculated an ex ante demand reduction of 67.11 kW.

Measure 7: VFD on 60 HP Motor

This measure claimed an annual energy savings of 104,273 kWh and DNV KEMA calculated an ex ante demand reduction of 13.42 kW.

Measure 8: VFDs on 50 HP Motors

This measure claimed an annual energy savings of 173,788 kWh and DNV KEMA calculated an ex ante demand reduction of 11.19 kW.

Measure 9: VFD of 50 HP Motor

This measure claimed an annual energy savings of 86,894 kWh and DNV KEMA calculated an ex ante demand reduction of 22.37 kW.

Measure 10: VFD on 30 HP Moto

This measure claimed an annual energy savings of 52,136 kWh and DNV KEMA calculated an ex ante demand reduction of 6.71 kW.

Measure 11: VFDs on 25 HP Motors

This measure claimed an annual energy savings of 86,894 kWh and DNV KEMA calculated an ex ante demand reduction of 11.19 kW.

Project Evaluation

A DNV KEMA field engineer visited the project sites on September 6th, 2012 to verify the measure installations and gather data on equipment model numbers, quantities, and control schemes. Table 26 summarizes the results of the installation verification.

Table 26: Verification Summary

Site	Equipment	Reported	Verified	Site Notes
Juvenile Camp	4-Ton package HVAC	4	4	
Sheriff's Honor Farm kitchen	14,000 CFM Make-Up Air Fan	1	1	Reported Trane M/N: YFD241, verified installation of Greenheck M/N: IGX-120-H32-H2
Sheriff's Admin Bldg: UPS	3-Ton package heat pumps	1	1	
Sheriff's Admin Bldg: Radio Comm Tower	5-Ton package heat pumps	2	2	
Central Plant	550-Ton chiller	1	1	
Central Plant	VFD on 150 HP pump motors	2	2	
Jail Air Handler Units	VFDs on 60 HP AH fan motors	1	1	
Jail Air Handler Units	VFDs on 50 HP AH fan motor	1	1	
Central Plant	VFDs on 50 HP hot water pump motors	2	2	
Cooling Tower #3	VFD on 30 HP cooling tower fan motor	1	1	
Jail Air Handler Units	VFDs on 25 HP AH fan motors	2	2	

Source: DNV KEMA analysis

For EEMs one, three and four, the ex post savings calculations utilized the same Pacific Northwest National Laboratory's Rooftop Unit Comparison Calculator[17] (RTUCC) online energy calculator. The calculator input parameters were altered from the ex ante values to reflect the equipment and operational characteristic that were observed during the on-site visit. For all of these simulations the reference location input was Sacramento, CA and building type input was "office-medium," with the exception of measure 3, for which the "office-small" building type was applied.

As with the DNV KEMA calculated ex ante demand savings, the ex post demand savings was calculated by as the difference of electrical power at full-load cooling capacity between the high-efficiency replacement units and that of the existing units (for Baseline 1 conditions) or that of normal-efficiency replacement units (for the Baseline 2 conditions).

Measure 1: 4-Ton Package HVAC Units

The following inputs were utilized in the Measure 1 ex post energy simulation calculation:

- Schedule: All week, all day
- Set point temperature: 71°F
- Cooling capacity: 48 kbtu/h in 1 stage
- Retrofit unit: 13 SEER, economizer enabled
- Existing unit: 9.0 SEER, economizer disabled
- Normal-efficiency replacement: 13 SEER, economizer enabled

The ex post analysis yielded an annual energy savings estimate of 19,696 kWh and a demand reduction of 6.28 kW for all four units when considering Baseline 1 conditions.

Measure 2: Make-up Air Unit

The Food Service Technology Center's Outdoor Air Load Calculator[18] was utilized to simulate annual energy saving and demand reduction from the replacement of the make-up air unit.

The following inputs were utilized in the Measure 2 ex post energy simulation calculation:

- Schedule: All week, 2 a.m. through 10 p.m.
- Set point temperature: 65°F
- Airflow capacity existing, retrofit/ normal-efficiency: 18,000 CFM, 14,000 CFM
- Supply motor efficiency retrofit, existing, normal-efficiency: 91 percent, 87 percent, 80 percent

17 http://www.pnnl.gov/uac/.

18 http://www.fishnick.com/ventilation/oalc/oac.php.

The ex post analysis yielded an annual energy savings estimate of 4,418 kWh and a demand reduction of 0.61 kW when considering Baseline 1 conditions.

Measure 3: 3-Ton Package Heat Pump Unit

The following inputs were utilized in the measure 3 ex post energy simulation calculation:

- Schedule: All week, all day
- Set point temperature: 71°F
- Cooling capacity: 36 kbtu/h in 1 stage
- Retrofit unit: 16.4 SEER, economizer enabled
- Existing unit: 9.2 SEER, economizer disabled
- Normal-efficiency replacement: 13 SEER, economizer enabled

The ex post analysis yielded an annual energy savings estimate of 4,676 kWh and a demand reduction of 1.48 kW when considering Baseline 1 conditions.

Measure 4: 5-Ton Package Heat Pump Units

For this measure, the two package heat pumps serve the same interior space operating like a two circuit air-conditioning system. One unit is set as the primary unit and has a cooling set point temperature of 68°F, while the other unit is set as an auxiliary unit, having cooling set point temperature of 73°F, which operates when the cooling load exceeds the capacity of the single unit. The assignments of the primary and auxiliary roles are alternated at regular intervals to ensure the units experience roughly the same level of use over time. The following inputs were utilized in the measure 4 ex post energy simulation calculation:

- Schedule: All week, all day
- Set point temperature (primary/ auxiliary): 68/ 73°F
- Cooling capacity: 56 kbtu/h in 2 stages
- Retrofit unit: 15.2 SEER, economizer enabled
- Existing unit: 10.0 SEER, economizer enabled
- Normal-efficiency replacement: 13 SEER, economizer enabled

The ex post analysis yielded an annual energy savings estimate of 6,059 kWh and a demand reduction of 4.64 kW for both units when considering Baseline 1 conditions.

Measure 5: 550-Ton Chiller Unit

For the measure 5 ex post savings analysis, DNV KEMA verified the ex ante savings spreadsheet calculation methodology and billing, performed a step-by-step review of the calculations as well as independently verified the ex ante NPLV values with a Trane

representative. DNV KEMA found no errors or in the ex ante annual energy savings calculations methodology and so verified the measure 4 annual energy savings to be 293,309 kWh when considering Baseline 1 conditions. For Baseline 2 conditions, DNV KEMA evaluated energy savings of the new unit against the minimum efficiency requirement for water cooled, eclectically operated, centrifugal chillers greater than 300-ton as listed in Table 112-D of the Energy Commission *2008 Building Energy Efficiency Standards.*[19] The minimum efficiency value used for the Baseline 2 condition was 0.550 kW per ton.

In reviewing the ex ante demand savings analysis, DNV KEMA identified an error in the methodology. The ex ante method mistakenly multiplies the percent change in chiller efficiency with the sum of the monthly average chiller demand, instead of using the highest monthly demand value or the average of the demand during peak months, thus overestimating the total demand reduction from this measure. Perhaps the ex ante analysis sought to identify potential cost savings associated with average demand reduction rather than peak demand savings. For the ex post demand savings DNV KEMA calculated the average of the chiller demand load from June to September as the existing chiller demand. This value was then multiplied by the percent change in NPLV and the ratio of replaced chillers to total chillers to produce at ex post demand savings.

The ex post analysis yielded a demand reduction of 57.88 kW when considering Baseline 1 conditions.

Measures 6 through 11: VFDs

For EEMs six through 11, the ex post annual energy savings and demand reduction were calculated according Equation 6 and Equation 10 in the CEE *Motor Efficiency, Selection, and Management*[20] (May 2011), which outline energy and power savings calculations for VFD measures. Equation 6[21], used for calculating annual energy consumption for VFD measures, is as follows:

$$Annual\ Energy\ kWh = \frac{Power\ (HP)}{\eta_{motor}} \times LF \times \frac{0.746\ kW}{HP} \times \frac{(\%\ FS)^3}{\eta_{VFD}} \times hours$$

Where,

Power (HP)	= the motor power, in units of horsepower
ηmotor	= the motor efficiency

19 http://www.energy.ca.gov/2008publications/CEC-400-2008-001/CEC-400-2008-001-CMF.PDF.

20 www.cee1.org/ind/motrs/CEEMotorGuidebook.pdf.

21 Equation 6 has been modified to provide kWh savings, in place of annual cost savings by removing the dollar per kWh factor from the original equation.

LF (Load Factor)	= the ratio of average motor load to rated motor load
% FS (Full Speed)	= the ratio of motor speed to full rated motor speed, expressed as a decimal
ηVFD	= the drive efficiency
Hours	= the annual operating hours for the motor

Annual energy savings are then calculated as the difference in annual energy consumption between the existing and retrofit scenarios.

Equation 10 from the CEE Motor Guide, used for calculating electric demand savings for VFD measures, is as follows:

$$Demand\ Savings\ kW = \frac{Power\ (HP)}{\eta_{motor}} \times LF \times \frac{0.746\ kW}{HP} \times \left[(\%\ FS_{motor})^3 - \frac{(\%\ FS_{VFD})^3}{\eta_{VFD}}\right]$$

Where,

Power (HP)	= the motor power, in units of horsepower
ηmotor	= the motor efficiency
LF (Load Factor)	= the ratio of average motor load to rated motor load
% FSmotor (Full Speed)	= the ratio of average motor speed to full rated motor speed, expressed as a decimal, for the pre-retrofit condition
% FSVFD (Full Speed)	= the ratio of average motor speed to full rated motor speed, expressed as a decimal, for the postretrofit condition
And ηVFD	= the drive efficiency

Values for percent full rated speed are based on observations during the site visits.

Measure 6: VFDs on 150 HP Motor

The equation inputs and calculation results for measure 6 are presented below in Table 27.

Table 27: Measure 6 VFD Inputs and Results

Input/ Output	Value	Units
Number of Motors/ Drives	2	#
Motor Power	150	HP
Motor Efficiency %	96	%
Load Factor %	50	%
Power Conversion	0.746	kW/ HP
% Full Rated Speed, Motor	100	%
Annual Operating Hours	2,288	Hrs/ yr

Input/ Output	Value	Units
Drive Efficiency %	97	%
% Full Rated Speed, VFD	71	%
Existing Annual Energy	267,531	kWh/ yr
Retrofit Annual Energy	98,020	kWh/ yr
Annual Energy Savings	169,511	kWh/ yr
Demand Savings	74.09	kW

Source: DNV KEMA analysis

Measure 7: VFD on 60 HP Motor

The equation inputs and calculation results for measure 7 are presented below in Table 28.

Table 28: Measure 7 VFD Inputs and Results

3Input/output	Value	Units
Number of Motors/ Drives	1	#
Motor Power	60	HP
Motor Efficiency %	96	%
Load Factor %	90	%
Power Conversion	0.746	kW/ HP
% Full Rated Speed, Motor	100	%
Annual Operating Hours	8,257	Hrs/ yr
Drive Efficiency %	97	%
% Full Rated Speed, VFD	71	%
Existing Annual Energy	347,576	kWh/ yr
Retrofit Annual Energy	130,064	kWh/ yr
Annual Energy Savings	217,513	kWh/ yr
Demand Savings	26.34	kW

Source: DNV KEMA analysis

Measure 8: VFDs on 50 HP Motors

The equation inputs and calculation results for measure 8 are presented below in Table 29.

Table 29: Measure 8 VFD Inputs and Results

Input/ Output	Value	Units
Number of Motors/ Drives	2	#
Motor Power	50	HP
Motor Efficiency %	94	%
Load Factor %	90	%

Input/ Output	Value	Units
Power Conversion	0.746	kW/ HP
% Full Rated Speed, Motor	100	%
Annual Operating Hours	8,076	Hrs/ yr
Drive Efficiency %	97	%
% Full Rated Speed, VFD	67	%
Existing Annual Energy	579,294	kWh/ yr
Retrofit Annual Energy	176,951	kWh/ yr
Annual Energy Savings	402,343	kWh/ yr
Demand Savings	49.82	kW

Source: DNV KEMA analysis

Measure 9: VFD of 50 HP Motor

The equation inputs and calculation results for measure 9 are presented below in Table 30.

Table 30: Measure 9 VFD Inputs and Results

Input/ Output	Value	Units
Number of Motors/ Drives	1	#
Motor Power	50	HP
Motor Efficiency %	96	%
Load Factor %	90	%
Power Conversion	0.746	kW/ HP
% Full Rated Speed, Motor	100	%
Annual Operating Hours	8,257	Hrs/ yr
Drive Efficiency %	97	%
% Full Rated Speed, VFD	71	%
Existing Annual Energy	289,647	kWh/ yr
Retrofit Annual Energy	108,386	kWh/ yr
Annual Energy Savings	181,261	kWh/ yr
Demand Savings	21.95	kW

Source: DNV KEMA analysis

Measure 10: VFD on 30 HP Motor

The equation inputs and calculation results for Measure 10 are presented below in Table 31.

Table 31: Measure 10 VFD Inputs and Results

Input/ Output	Value	Units
Number of Motors/ Drives	1	#

Input/ Output	Value	Units
Motor Power	30	HP
Motor Efficiency %	94	%
Load Factor %	90	%
Power Conversion	0.746	kW/ HP
% Full Rated Speed, Motor	100	%
Annual Operating Hours	2,288	Hrs/ yr
Drive Efficiency %	97	%
% Full Rated Speed, VFD	71	%
Existing Annual Energy	49,236	kWh/ yr
Retrofit Annual Energy	18,039	kWh/ yr
Annual Energy Savings	31,197	kWh/ yr
Demand Savings	13.63	kW

Source: DNV KEMA analysis

Measure 11: VFDs on 25 HP Motors

The equation inputs and calculation results for Measure 11 are presented below in Table 32.

Table 32: Measure 11 VFD Inputs and Results

Input/ Output	Value	Units
Number of Motors/ Drives	2	#
Motor Power	25	HP
Motor Efficiency %	96	%
Load Factor %	90	%
Power Conversion	0.746	kW/ HP
% Full Rated Speed, Motor	100	%
Annual Operating Hours	2,288	Hrs/ yr
Drive Efficiency %	97	%
% Full Rated Speed, VFD	52	%
Existing Annual Energy	80,259	kWh/ yr
Retrofit Annual Energy	11,690	kWh/ yr
Annual Energy Savings	68,569	kWh/ yr
Demand Savings	29.97	kW

Source: DNV KEMA analysis

Savings Results and Discussion

The project saved 1,398,550 kWh of electric energy and reduced summer on-peak demand by 286.7 kW in the first year when considering Baseline 1 conditions.

Measures 1, 3 & 4: Package HVAC Units

Sources of uncertainty regarding these HVAC calculations included the assumed level of degradation of the existing equipment, reliance on-site contact reported preretrofit operating conditions, and the assumptions inherent in the bin analysis method regarding equipment sizing and building cooling loads being primarily weather dependent.

Measure 2: Make-up Air Unit

Sources of uncertainty regarding these ventilation calculations included the assumed efficiency and performance of the existing equipment, reliance on-site contact reported preretrofit operating conditions, reliance on-site contact reported energy consumption to calibrate pre-retrofit modeled energy use, assumptions regarding the existing kitchen exhaust system, the total static pressure for the make-up air unit, equipment sizing and building cooling and heating loads.

Measure 5: 550-Ton Chiller Unit

Sources of uncertainty regarding the spreadsheet analysis of the chiller savings included reliance on non-weather normalized billing data, assumptions regarding baseline (non-cooling plant) energy and power consumption, the accuracy of the chiller and pump annual operating hours and loading factors.

Measures 6 through 11: VFDs

Sources of uncertainty regarding these VFD savings calculations include the following assumed or calculated values: load factors; percent full rated speeds, annual operating hours, and drive efficiency.

Ex Post Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

EUL values for the four measures were sourced from the 2011 DEER database, while the RULs were calculated from the age of the existing equipment at the time of retrofit and the measure EUL. Measures that were past their EUL but still operational were assigned an RUL of 1 year.

Table 33 displays the first year savings used to calculate the Baseline 1 and Baseline 2 life-cycle savings. Table 33 also lists the effective and remaining useful lives of each measure. Table 34 presents the electrical energy, electrical demand, and natural gas energy savings according to Baseline 1 conditions for each year the measure is in place up to the end of the measure's EUL. Table 35 presents the yearly life-cycle savings values according to Baseline 2 conditions.

Table 33: Values used in Ex Post Life-cycle Savings Calculations

Measure	Early Replacement			Expected Replacement			EUL (years)	RUL (years)
	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)		
4-Ton Package HVAC Units	19,696	6.28	0	0	0.00	0	15	1
Make-Up Air Unit	4,418	0.61	0	1,801	0.25	0	15	1
3-Ton Package HP Unit	4,676	1.48	0	2,435	0.34	0	15	1
5-Ton Package HP Units	6,059	4.64	0	608	0.47	0	15	1
550-Ton Chiller Unit	293,309	57.88	0	278,477	54.95	0	20	1
VFDs on 150 HP Motors	169,510	74.09	0	169,510	74.09	0	15	0
VFD on 60 HP Motor	217,512	26.34	0	217,512	26.34	0	15	0
VFDs on 50 HP Motors	402,343	49.82	0	402,343	49.82	0	15	0
VFD on 50 HP Motor	181,261	21.95	0	181,261	21.95	0	15	0
VFD on 30 HP Motor	31,197	13.63	0	31,197	13.63	0	15	0
VFDs on 25 HP Motors	68,569	29.97	0	68,569	29.97	0	15	0
Total	1,398,550	286.69	0	1,353,713	271.81	0	-	-

Source: DNV KEMA analysis

Table 34: Baseline 1 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	1,398,550	286.69	0
2	2013	1,398,550	286.69	0
3	2014	1,398,550	286.69	0
4	2015	1,398,550	286.69	0
5	2016	1,398,550	286.69	0
6	2017	1,398,550	286.69	0
7	2018	1,398,550	286.69	0
8	2019	1,398,550	286.69	0

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
9	2020	1,398,550	286.69	0
10	2021	1,398,550	286.69	0
11	2022	1,398,550	286.69	0
12	2023	1,398,550	286.69	0
13	2024	1,398,550	286.69	0
14	2025	1,398,550	286.69	0
15	2026	1,398,550	286.69	0
16	2027	293,309	57.88	0
17	2028	293,309	57.88	0
18	2029	293,309	57.88	0
19	2030	293,309	57.88	0
20	2031	293,309	57.88	0
Life-cycle Total		22,444,795 kWh	4,590 kW-years	0 Therms

Source: DNV KEMA analysis

Table 35: Baseline 2 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	1,398,550	286.69	0
2	2013	1,353,713	271.81	0
3	2014	1,353,713	271.81	0
4	2015	1,353,713	271.81	0
5	2016	1,353,713	271.81	0
6	2017	1,353,713	271.81	0
7	2018	1,353,713	271.81	0
8	2019	1,353,713	271.81	0
9	2020	1,353,713	271.81	0
10	2021	1,353,713	271.81	0
11	2022	1,353,713	271.81	0
12	2023	1,353,713	271.81	0
13	2024	1,353,713	271.81	0
14	2025	1,353,713	271.81	0
15	2026	1,353,713	271.81	0
16	2027	278,477	54.95	0
17	2028	278,477	54.95	0
18	2029	278,477	54.95	0

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
19	2030	278,477	54.95	0
20	2031	278,477	54.95	0
Life-cycle Total		21,742,917 kWh	4,367 kW-years	0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Inyo, County of (CBG-09-015)

Site Summary

Inyo County completed a wide ranging lighting project including fixture retrofits and occupancy sensor installations in 36 buildings distributed across a 211 mile range in the county. The county additionally installed two Vending Miser controllers in their courthouse. The project scope originally included boiler control measures, but these were taken out of the final project scope.

Table 36 below summarizes the energy savings achieved by the retrofit project.

Table 36: Energy Savings Summary

Measure	Ex Ante		Ex Post		Realization Rate	
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)	Electric	Gas
Lighting Retrofit	348,341	0.0	396,200	0.0	114%	N/A
Lighting Controls	2,234	0.0	2,234	0.0	100%	N/A
Vending Miser Controls	3,224	0.0	3,224	0.0	100%	N/A
Total	353,799	0.0	401,658	0.0	114%	N/A

Source: DNV KEMA analysis

Life-cycle savings were calculated for each EEM based on DEER EUL values. Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment is exceeded

Table 37: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Natural Gas Energy Savings (Therms)
Baseline 1	5,976,995 kWh	0.0 Therms
Baseline 2	5,976,995 kWh	0.0 Therms

Source: DNV KEMA analysis

Project Description

Inyo County completed a county wide overhaul of its lighting fixtures. The retrofit affected 36 buildings across six towns and 211 miles of road. 2,093 pre-existing fixtures were either updated with new lamps and ballasts or removed (note that these were not complete fixture replacements), leaving 2,091 retrofitted fixtures in their place. Of the affected fixtures, more than 80 percent were linear fluorescent. The remaining fixtures consisted of screw-in incandescent lights, halogen flood lights, and MH fixtures. These fixtures were retrofit using a combination of CFLs, halogen lights, and linear fluorescent fixtures. Additionally, 73 occupancy sensors were installed throughout the affected buildings. The facilities affected by this project are listed in Table 38 below along with their corresponding town or census designated place (CDP), the affected fixture count, and the occupancy sensor installation count.

Table 38: Project Scope Summary

Facility	Town/CDP	Affected Fixture Quantity	Occupancy Sensors
Legion Hall/Senior Center - Big Pine Branch	Big Pine	37	0
Inyo Animal Shelter	Big Pine	9	0
Inyo County Library - Bishop Branch	Bishop	55	2
County Services Building	Bishop	56	4
Health and Human Services - Bishop Branch	Bishop	198	12
Inyo County Administrative Services - Bishop Branch	Bishop	74	3
D.A./Child Services - Bishop Branch	Bishop	47	0
WIC - Women, Infants, and Children	Bishop	29	3
HHS and Probation Dept. Bishop	Bishop	101	0
Bishop Senior Center	Bishop	54	2
Bishop Road Shop	Bishop	20	1

Facility	Town/CDP	Affected Fixture Quantity	Occupancy Sensors
Bishop Airport - Terminal	Bishop	5	2
Bishop Airport - Maintenance Shop	Bishop	9	0
Bishop Airport - Engineering Trailer	Bishop	9	0
Bishop Airport - Quonset Hut	Bishop	13	3
Sheriff's Posse Hut	Bishop	40	2
Bishop Road Yard & Construction Trailer	Bishop	22	1
Inyo County Courthouse	Independence	171	5
Inyo County Courthouse Annex	Independence	256	8
Inyo County Administration Building	Independence	87	0
Inyo County Jail	Independence	96	0
Inyo County Jail - Admin	Independence	43	0
Inyo County Juvenile Detention Facility	Independence	106	2
Health and Human Services - Independence Branch	Independence	70	3
Inyo County Water Department	Independence	58	4
Statham Hall Senior Center	Independence	77	0
Eastern California Museum	Independence	73	2
Inyo County Road Department - Independence Branch	Independence	63	9
Legion Hall/Senior Center - Independence Branch	Independence	60	0
Motor Pool Maintenance Shop	Independence	23	1
Health and Human Services - Lone Pine Branch	Lone Pine	28	1
Inyo County Library - Lone Pine Branch	Lone Pine	16	0
Inyo County Sheriff's Substation - Lone Pine Branch	Lone Pine	29	3
Shoshone Road Shop	Shoshone	10	0
Tecopa Senior Center	Tecopa	38	0
Tecopa Library/HHS	Tecopa	9	0

Source: DNV KEMA analysis

Ex Ante Savings

Ex ante savings were calculated by Los Angeles Department of Water and Power (LADWP) and Southern California Edison (SCE) as part of initial surveys conducted for utility program incentives prior to measure implementation. The original versions of these spreadsheets were not provided for review. However, a version modified by the site contact following measure implementation was provided. This spreadsheet included the operating hour assumptions from the original LADWP and SCE audits. Additionally, the spreadsheet exhibited the savings calculation methodologies utilized by the utilities to estimate savings. As is appropriate for lighting measures, savings were calculated for each affected group of fixtures by multiplying the difference between the installed and baseline wattages by the fixtures' estimated operating hours. Occupancy sensor savings were not calculated, although sensor installation was cataloged.

Project Evaluation

This project was somewhat unique in that the evaluation site visit was conducted while the site contact was still surveying the facilities and compiling a final scope document listing the completed work. The fast-tracked timing of the site visit was dictated by impending project deadlines that were ultimately changed. Although the site contact was not able to provide a project scope document listing the finalized fixture types and counts in each building, he did provide a spreadsheet produced prior to the retrofit listing the projected gross fixture retrofit quantities in each building. The evaluation team utilized this document to select the facilities with the largest number of affected fixtures for verification.

At the beginning of the verification visit, the site contact was asked to provide general operating schedules for each of the 36 buildings affected by the project. The operating schedules collected during this process were later utilized to update many of the initial schedule estimates made by LADWP and SCE. In other cases, modifications to the original utility estimates were not made. For instance, many buildings have storage, janitorial, restroom, hallway, and exterior spaces that operate on different schedules than the rest of a given building; the original utility calculations reasonably accounted for this.

Following a review of each building's operating schedules, the site contact and the evaluator traveled throughout the county and verified fixture and occupancy sensor installations in 14 different buildings. While the site contact did not have a final project scope document, he did have detailed floor layouts with hand-documented fixture counts for each room. Using these documents, the site contact and evaluator walked throughout each building and compared his documented fixture and occupancy sensor counts with the installed fixture and occupancy counts. In general, the site contact's fixture records were very accurate. In places that they were not, the contact made notes to update his records. While surveying the county courthouse, two Vending Miser controllers were also verified to be installed as proposed. Table 39 below includes a summary of findings for each audited building.

Table 39: Site Verification Record

Building	Verification Notes
Bishop Airport Terminal	Implementation consistent with the contact's record.
Bishop Senior Center	Implementation consistent with the contact's record with the exception of one fixture.
Engineering Trailer	Implementation consistent with the contact's record.
Inyo County Administrative Services - Bishop	Verifiable fixtures consistent with the contact's record; the record was unclear in certain areas, making complete verification impossible.
Inyo County Courthouse	A number of errors were identified with the contact's record, but he made modifications to the record on the spot to account for the errors. Two Vending Misers were found installed as proposed.
Inyo County Courthouse Annex	Only the second floor (of 2) of this facility was verified. The verified components were consistent with the contact's record.
Inyo County Juvenile Detention Facility	Verified the administrative (non-inmate) area of the facility. The site contact's implementation record was incomplete at the time of verification.
Inyo County Road Department – Independence	Implementation consistent with the contact's record
Inyo County Sheriff's Substation - Lone Pine	Implementation consistent with the contact's record
Legion Hall/Senior Center - Big Pine	Implementation consistent with the contact's record
Maintenance Shop	Implementation consistent with the contact's record
Quonset Hut	Implementation consistent with the contact's record
Sheriff's Posse Hut	Implementation consistent with the contact's record
Statham Hall Senior Center	Implementation consistent with the contact's record

Source: DNV KEMA analysis

At the end of the site visit, the evaluation team was confident that the measures had been installed as proposed. Following the site visit, the site contact made modifications to his records based on the evaluation walkthroughs. The contact additionally surveyed the remaining buildings over the following week. The contact then provided the evaluation team with a finalized spreadsheet detailing the scope of work in each building, including both pre and postretrofit fixture counts and occupancy sensor installation records. The evaluation team was confident that the provided records were accurate because of the consistent quality of the notes that the site contact utilized during the site visit (see Table 39).

Using the fixture record provided by the site contact and operating scheduled data collected while on-site, savings for each group of retrofit fixtures were calculated using the following formula:

$$kWh_{saved} = \frac{(n_{fixt-pre}W_{pre}h_{op} - n_{fixt-post}W_{post}h_{op}f_c)}{1000}$$

Where,

kWh_{saved}	= Lighting energy savings (kWh)
$n_{fixt-pre}$	= Pre-retrofit number of fixtures in a given lighting group
$n_{fixt-post}$	= Postretrofit number of fixtures in a given lighting group
W_{pre}	= Preexisting fixture wattage (W)
W_{post}	= Postretrofit fixture wattage (W)
h_{op}	= Fixture group operating hours
f_c	= Postretrofit lighting control operating hour scale factor
1000	= Watt to kilowatt conversion factor (W/kW)

For fixture groups without occupancy sensors, the postretrofit operating hour scale factor, f_c, was set to 100 percent; for fixture groups with occupancy sensors, f_c was set to 70 percent. Savings from all fixture groups were summed to arrive at the final savings estimate.

Vending Miser controls were assigned .184 kW/hour in savings based on the deemed savings listed in Massachusetts Technical Reference Manual.[22]

Savings Results

Relative to the pre-existing conditions (Baseline 1), the project saved a total of 401,658 kWh, yielding a 115 percent realization rate. Since only the lamps and ballasts were replaced as opposed to the entire fixtures (in nearly all cases), Title 24 was not triggered for the Baseline 2 calculation. Instead, the county would have been able to replace the existing lamps and ballasts with identical components in the absence of the EECBG. Furthermore, neither the lighting controls nor the Vending Misers would have been installed in the absence of the program. As such, the pre-existing equipment served as the baseline for the expected replacement calculation, resulting in identical savings of 401,658 kWh and a realization rate of 115 percent relative to Baseline 2.

Discussion

A full explanation for the discrepancy between the ex post savings and the ex ante savings is not possible since the savings calculations used to derive the ex ante savings were not provided. However, in the savings spreadsheet provided by the site contact following his review of the implemented project scope, savings did increase by 46,549 kWh relative to the ex ante claim. The project scope changes that caused the difference between the original ex ante submission and the contact's final revision are unknown. The evaluation team made further modifications to the lighting operating schedules in the savings spreadsheet based on the site collected

22 http://www.ma-eeac.org/docs/MA%20TRM_2011%20PLAN%20VERSION.PDF.

scheduling data, increasing the savings estimate an additional 1,310 kWh. Since neither the ex ante calculations (as determined from the tracking data) nor the site contact's revised calculations accounted for occupancy sensor or Vending Miser savings, adding these two elements increased the savings by 2,234 kWh and 3,224 kWh respectively. Altogether, these modifications yielded a 15 percent increase in savings relative to the initial ex ante estimate.

Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

Table 40 below provides the annual energy savings estimates that fed into the life-cycle savings calculations, as well as the EULs for the installed measures.

Table 40: Values Used in Life-cycle Savings Calculations

Measure	Early Replacement		Expected Replacement		EUL (years)	RUL (years)
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)		
Lighting retrofit	396,200	0.0	396,200	0.0	15	0.0
Lighting Controls	2,234	0.0	2,234	0.0	8	0.0
Vending Misers	3,224	0.0	3,224	0.0	5	0.0

Source: DNV KEMA analysis

Table 41 provides life-cycle savings for the project relative to Baseline 1 and Baseline 2.

Table 41: Life-cycle Savings Relative to Baseline 1 and Baseline 2

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Natural Gas Energy Savings (Therms/yr)
1	2011	401,658	-
2	2012	401,658	-
3	2013	401,658	-
4	2014	401,658	-

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Natural Gas Energy Savings (Therms/yr)
5	2015	401,658	-
6	2016	398,435	-
7	2017	398,435	-
8	2018	398,435	-
9	2019	396,200	-
10	2020	396,200	-
11	2021	396,200	-
12	2022	396,200	-
13	2023	396,200	-
14	2024	396,200	-
15	2025	396,200	-
16	2026	-	-
Life-cycle	Total	5,976,995 kWh	0.0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Nevada, County of(CBG-09-017-A)

Site Summary

Nevada County completed a retrofit project consisting of HVAC, domestic hot water (DHW), and lighting measures at the county jail, as well lighting measures at three other county buildings. Table 43 below summarizes the energy savings achieved by the measures comprising the Nevada County retrofit project. Since retrofitting hundreds of lights affects the heating and cooling energy use of a building, such energy changes were calculated for EEM4 and EEM5. However, these interactive effects have been excluded from the reported results to remain consistent with the methodology employed across all sites in the EECBG evaluation sample.

Table 42: Energy Savings Summary

Measure	Ex Ante		Ex Post		Realization Rate	
	Electric - Excluding Interactive Effects (kWh)	Gas – Excluding Interactive Effects (Therms)	Electric - Excluding Interactive Effects (kWh)	Gas - Excluding Interactive Effects (Therms)	Electric	Gas
EEM1: Jail Packaged HVAC Retrofit	170,945	2,037	78,098	12,700	46%	623%
EEM2: Jail EMS Upgrade	4,206	3,955	4,206	612	100%	15%
EEM3: Jail Boiler Retrofit	726	6,736	2,667	11,021	367%	164%
EEM4: Jail Lighting Retrofit	184,293	-	93,154	-	51%	N/A
EEM5: County Buildings Lighting Retrofit	42,949	-	62,519	-	146%	N/A
Total	403,119	12,728	240,644	24,332	60%	191%

Source: DNV KEMA analysis

Life-cycle savings were calculated for each EEM based on DEER EUL values. Life-cycle savings were calculated relative to two baselines. Baseline 1 assumed that the pre-existing equipment would have operated for the full EUL of the new equipment. Baseline 2 used the pre-existing equipment as the measure baseline only so long as it had RUL. Thereafter, an expected equipment baseline was used for the RUL of the new equipment.

Table 43: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Natural Gas Energy Savings (Therms)
Baseline 1	3,623,010 kWh	420,085 Therms
Baseline 2	2,736,642 kWh	176,749 Therms

Source: DNV KEMA analysis

Project Description

The project is subsequently described on a measure-by-measure basis.

EEM1: 30 packaged HVAC systems, which were each in excess of 15 years old, were replaced with modern code compliant units ranging in size from 3 to 8.5 tons. The newly installed units are equipped with air side single point temperature economizers to reduce mechanical cooling when outdoor free cooling is available.

EEM2: The jail's pre-existing Yamas Barber Colemen controls were replaced with Delta Controls. The new controls allowed the jail to implement setback control strategies for each of the new HVAC units. Prior to the retrofit, nearly all HVAC units ran 24/7 on a fixed set point schedule.

EEM3: Two pre-existing, 1,200 MBH Jarco Hot Water Heaters (71.2 percent thermal efficiency) and one backup 185 MBH Jarco Hot Water Heater (75.7 percent combustion efficiency) were replaced with two 500 MBH State Industries Ultra Force Condensing Hot Water Heaters (95 percent thermal efficiency). These units provide DHW for kitchen operations, lavatory sinks, showers, and laundry applications. Additionally, three 1/12 hp hot water circulation pumps that previously ran continuously were removed.

EEM4: A comprehensive lighting retrofit was completed at the county jail. The measure scope included relamping and reballasting 676 2-lamp T8 fixtures, 66 1-lamp T8 fixtures, and 21 4-lamp T8 fixtures. Additionally, 15 incandescent exit signs were replaced with LED equivalents.

*Note that the ex ante savings spreadsheet reflected a total of 814 fixtures, as opposed to the sum of 778 indicated by the preceding quantities, because line items were included for 36 fixtures that were not affected by the retrofit.

EEM5: Three other county buildings were also subject to comprehensive lighting retrofits. First generation T-8 lights and T-12 lights were replaced with low wattage T-8 fixtures throughout all three buildings. The measure scope included: 301 fixtures in the Joseph Building, which contains court rooms and law offices; 84 fixtures in the Government Center Building, which contains jail operations, the sheriff dispatch offices and the Environmental Health Department; and 70 fixtures in the Truckee Library.

Ex Ante Savings

Ex ante savings algorithms are discussed below on a measure-by-measure basis.

EEM1: Savings calculations pertaining to the jail HVAC retrofit were not provided for review. The methodology used to determine HVAC savings is unknown.

EEM2: Savings calculations for the controls retrofit were not provided for review. The analysis methodology is unknown. In the database update of 9/17/12, no electrical savings were included for this measure.

EEM3: Savings calculations were not provided for the hot water heating retrofit. The savings calculation methodology is unknown.

EEM4: Lighting retrofit savings were assessed using an itemized savings calculation spreadsheet. For each group of fixtures, savings were calculated by multiplying the wattage differential between the pre-existing and installed fixtures by the estimated operating hours for those fixtures. All fixtures included in the analysis were presumed to operate 8,760 hours per year. Interactive effects savings were additionally calculated based on the reduction in cooling load expected to result from the retrofit. The provided spreadsheets did not have live equations, so it was not possible to fully assess the interactive effects savings calculation methodology. However, the interactive effects savings for each lighting group were a constant scale factor of approximately 12 percent of the lighting energy use reduction. In all likelihood, a fraction of the annual lighting load reduction was assumed to occur during hours with building cooling loads. A cooling system efficiency was then probably applied to this portion of the lighting savings to determine cooling savings. A heating penalty was not assessed in the interactive effects savings calculation. [Note: interactive effects are not included in the savings cited in any of the tables for either the ex ante or ex post analyses; thus the ex ante value shown in Table 43 is 12 percent less (184,293 kwh) than the 206,741 kwh provided in project documentation].

EEM5: Lighting retrofit savings in the remaining county buildings were assessed using an identical methodology employed for EEM4. The only difference between the two analyses was that not all fixtures were presumed to operate continuously throughout the year in the EEM5 analysis.

Project Evaluation

EEM1: The first step in evaluating savings from the county jail packaged unit retrofit was simply verifying that the packaged systems had been installed. During a site visit, the evaluation team was able to confirm that each of the 30 packaged systems claimed as part of the grant had been installed as proposed.

The unit schedules and set points specific to the units *prior* to the retrofit were also collected. While the postretrofit scheduling updates undoubtedly resulted in energy savings, those savings were attributable to the controls retrofit, which was assessed separately under EEM2.

Model performance information for the pre-existing units was also verified following the site visit via manufacturer's performance data. In the course of the savings analysis, each pre-existing system efficiency value (both heating and cooling) was derated 10 percent to account for performance degradation.

Project savings were calculated using an estimated full load hours approach, where the EFLH values were determined by applying the pre-existing unit schedules and temperature dependent heating and cooling load profiles to TMY3 data from the nearby weather station in Blue Canyon, CA. After determining cooling and heating EFLH for each unit affected by the retrofit, cooling savings were determined according to the equation,

$$kWh_{cool-i} = Cap_{cool-i} * \left(EFLH_{cool-i-pre} * \frac{1}{EER_{pre}} - EFLH_{cool-i-post} * \frac{1}{EER_{post}}\right) \quad (1)$$

kWh_{cool-i}	= Cooling savings for unit *i*
$EFLH_{cool-i-pre}$	= Equivalent full load hours for unit *i* preretrofit
$EFLH_{cool-i-post}$	= Equivalent full load hours for unit *i* postretrofit
Cap_{cool-i}	= Cooling capacity of unit *i* (kBtuh)
EER_{pre}	= Efficiency of pre-existing unit *i* (kBtu/kWh)
EER_{post}	= Efficiency of installed unit *i* (kBtu/kWh)

Note that equivalent full load hours were not the same before and after the retrofit because the installed units have functioning economizers, allowing them to take advantage of free cooling. By contrast, the pre-existing units did not have economizers. As such, the EFLH values for the pre-retrofit units were greater than the EFLH values for the postretrofit units.

Heating savings were determined using the formula,

$$Therms_{heat-i} = \frac{Cap_{heat-i}}{100} * \left(EFLH_{heat-i-pre} * \frac{1}{\eta_{pre}} - EFLH_{heat-i-post} * \frac{1}{\eta_{post}}\right) \quad (2)$$

$Therms_{heat-i}$	= Heating savings for unit *i*
$EFLH_{heat-i-post}$	= Equivalent full load hours for unit *i* postretrofit
Cap_{heat-i}	= Heating capacity of unit *i* (kBtuh)
η_{pre}	= Thermal efficiency of pre-existing unit *i*
η_{post}	= Thermal efficiency of the installed unit *i*

In Equation 2, the EFLH values were equivalent pre and postretrofit since economizing does not take place in heating mode.

Cooling and heating savings were also calculated relative to an expected replacement baseline, which utilized current Title 24 and Title 20 standards as the baselines for cooling and heating efficiency respectively. Current Title 24 standards also require economizers on all units greater than 6.25 tons in capacity. As such, the EFLH values were also modified for the pre-retrofit case under the expected replacement baseline.

EEM2: The HVAC controls retrofit generated savings by giving facility personnel greater control over the set points and schedules of the jail's HVAC equipment. Savings were therefore calculated on the basis of the heating and cooling load reductions resulting from the revised schedules implemented as part of the controls retrofit.

To account for these savings, the equivalent full load hour values included in Equations 1 and 2 above for the *postretrofit* scenario were updated to reflect the impact of shortened unit schedules and setback cooling and heating set points. Savings were then calculated again using Equations 1 and 2. The difference between the EEM1 savings and the savings calculated with these revised schedules were the savings attributable to the controls retrofit. Savings were calculated relative to both the pre-existing equipment baseline and the expected replacement baseline in this manner.

EEM3: Hot water heater installation was verified during the same site visit to the jail conducted for the packaged HVAC project. Two 95 percent efficient State Industries Ultra Force Condensing Water Heaters were found as expected. Additionally, only 2 hot water pumps were found, suggesting that three of the five original pumps had been removed as proposed.

The evaluation team determined savings using a spreadsheet calculation informed by load data gathered during the site visit. It was not possible to rely on utility billing data to calculate savings because other large gas users on-site, such as kitchen equipment and the HVAC packaged units, are also included in the gas bills.

Site contacts were surveyed regarding each of the hot water end users at the facility: showers, lavatory faucets, kitchen equipment, and laundry equipment. Data provided by the contacts were subsequently used to estimate facility loads. For instance, the shower load was determined based on the number of inmates at the jail (roughly 200), the average number of showers per inmate per day (1.5), the average shower length (10 minutes), the average shower head flow rate (2.5 GPM[23]), the average shower temperature (105 F[1]), and the average groundwater temperature (52 F). Similar data were gathered and utilized for the lavatory faucets, kitchen equipment, and laundry equipment. Loads from all equipment were then summed to determine the annual hot water heating load for the jail, which was estimated at 30,450 therms. On an hourly basis, 30,450 therms translates to an average of 350 kBtuh, or 35 percent of the DHW plant's capacity . An average annual load factor of 35 percent is reasonable for a high use DHW system.

Savings were determined by comparing the gas use required of the pre-existing boilers and the installed boilers to meet the hot water heating load. This was done by simply dividing the hot water heating load by the pre-existing case and installed case efficiencies and then taking the difference between the two values. For the pre-existing case, efficiency values were appropriated from the feasibility study, which used a thermal efficiency of 71.2 percent for the two 1,200 MBH boilers and a combustion efficiency of 75.7 percent for the 185 MBH boiler. The small boiler's combustion efficiency was derated 2 percent to account for additional thermal losses not included in combustion efficiency. A capacity-weighted average of the three pre-existing boilers was then taken to arrive at the pre-existing case efficiency of 71.4 percent used

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23 Based on the *Mid-Atlantic Technical Reference Manual, Version 1.1, Pg. 38-39,* http://neep.org/uploads/EMV%20Forum/EMV%20Products/Mid%20Atlantic%20TRM_V1.1.pdf.

in the evaluation analysis. The postretrofit thermal efficiency of 95 percent was appropriated directly from manufacturer's literature.

Electric savings were calculated based on the load reduction caused by removing 3 1/12th horsepower pumps, running 8,760 hours per year at an estimated 80 percent load factor.

Savings were also calculated relative to a standard practice equipment baseline. The only difference between these two calculations was that a code compliant Title 20 efficiency was used for the base case efficiency.

EEM4: A sample of the fixtures subject to the lighting retrofit was verified during the facility site visit. Of the 778 fixtures (36.4 kW) claimed for retrofit savings, 209 (10.4 kW) were verified during the site visit. The site visit revealed that the fixture quantities and types claimed in the feasibility study documentation—and thus in the finalized savings—were different from what was actually installed. According to feasibility documentation, the 209 verified fixtures should have accounted for 10.4 kW in connected load. In reality, where 209 fixtures were expected to be found, 227 fixtures were identified and the connected load was 13.1 kW. To account for the discrepancy found within the verification sample, the wattage of the remaining unverified fixtures was scaled in proportion to the differential between the identified wattage and the expected wattage (13.1 kW/10.4 kW) in the subsequent analysis.

The county later contested the fixture count utilized in the evaluation analysis, stating that there were in fact 18 fewer fixtures in the facility than indicated in the analysis. To account for this discrepancy, the fixture counts outside of the area verified as part of the evaluation were scaled such that the total fixture quantity for the facility matched the total claimed by the county.

During the site visit, facility personnel were asked to provide revised operating hour estimates for all fixtures included in the retrofit. Using the fixture verification results and the revised lighting operating schedules, savings were calculated by multiplying the pre and postretrofit wattage differential for each group of fixtures by the operating hours specific to that group.

EEM5: As with EEM4, a sample of fixtures at each of the county buildings affected by the lighting retrofit was surveyed. Lighting schedules specific to each building were also gathered from each site contact. Table 44 below compares the fixture samples that were verified at each building with the gross project scope.

Table 44: County Building Fixture Verification Sampling

	Verification Sample		Total Scope		Verified Percentage	
Building	Count	Connected Load (kW)	Count	Connected Load (kW)	Count	Connected Load
Joseph	169	10.0	301	17.1	56%	58%
Government Center	66	3.6	84	4.5	79%	81%
Truckee Library	70	3.0	70	3.0	100%	100%

Source: DNV KEMA analysis

Table 45 below summarizes the differences between the claimed connected loads in the feasibility study and what was actually observed on-site at each building.

Table 45: Evaluation and Feasibility Study Connected Load Comparison

Building	Connected Load (Verification Sample)		Scale Factor
	Feasibility Study	Observed	
Joseph	10.0	7.3	73%
Government Center	3.6	2.4	67%
Truckee Library	3.0	3.1	104%

Source: DNV KEMA analysis

The scale factors in Table 45 were subsequently applied to the fixtures that were not sampled in each building to arrive at revised wattage estimates for the postretrofit case. Savings for each of the county buildings were then calculated using a nearly identical methodology to that used for EEM4, albeit a slight modification was made to account for the fact that occupancy sensors were installed in a very small number of areas. For those areas with occupancy sensors, a 30 percent reduction in installed operating hours was assumed relative to the scheduled operating hours.

Savings Results

Relative to the pre-existing equipment installed for each EEM, the project saved a total of 240,645 kWh and 24,332 therms annually. These revised savings estimates yielded realization rates of 60 percent and 191 percent for electricity and gas respectively. Compared to expected replacement equipment, the project saved 177,333 kWh and 8,728 therms.

Discussion

The reasons for the savings discrepancies cited in Table 45 above are discussed on a measure-by-measure basis subsequently.

EEM1: The packaged unit retrofit saved considerably fewer kWh than estimated in the feasibility study, but considerably more therms. It is unclear why this discrepancy exists because the ex ante savings analysis was not provided for review.

EEM2: As with EEM1, the ex ante saving analysis for the EMS upgrade was not provided for review, so it was not possible to assess the reasons for the substantial savings decrease for this measure. Nonetheless, it is reasonable to speculate that the scheduling changes assumed in the ex ante analysis for the new packaged systems were more dramatic than those implemented in practice. Since the majority of the units serving the jail still operate continuously throughout the day when cooling loads peak, the revised scheduling did not generate significant cooling savings. Furthermore, during the day time, the cooling set points did not change as a result of the retrofit; only the nighttime setback temperatures were modified. Heating savings were

similarly reduced because many of the units were left on full day occupied schedules, or schedules with relatively short setback periods.

EEM3: The ex ante savings analysis for the jail boiler project was not supplied. Therefore it was not possible to assess why the evaluated gas savings exceeded the tracking savings by 64 percent. Since the same efficiencies were likely utilized in the analysis, it is reasonable to assume that the tracking analysis was based on a lower load estimate than that used in the evaluation calculation.

It is difficult to speculate as to why the electric savings differed between the evaluation and tracking estimates. The evaluation used the liberal assumption that all three removed pumps operated continuously throughout the year at an 80 percent load factor; it is possible that the ex ante analyses included more conservative assumptions. The evaluation team felt justified in assuming that the pumps operated continuously since they did not have timer (or other) controls according to the site contact.

EEM4: Evaluated lighting savings differed markedly from the claimed savings for two reasons. First, the ex ante analysis assumed that all lights in the jail affected by the retrofit operated 8,760 hours per year. By contrast, the evaluation estimated that the jail's lights operate for 6,621 hours per year on average (as weighted by connected load). This factor alone accounted for more than half the reduction in savings. The savings were further reduced because the fixture quantity and type composition observed during the evaluation site visit resulted in a much greater connected load than originally proposed in the feasibility study.

EEM5: Evaluated savings exceeded the ex ante estimate predominantly because the installed fixtures were observed to be, in the aggregate, of lower wattage than proposed in the ex ante analysis. Whereas the ex ante analysis forecast that the postretrofit connected load would be 26.8 kW, the evaluation revealed that the postretrofit connected load was approximately 20.9 kW.

Life-cycle Savings

Table 46 below provides the annual energy savings estimates that fed into the life-cycle savings calculations, as well as the EULs for the installed measures.

Table 46: Values Used in Life-cycle Savings Calculations

Measure	Savings Relative to Pre-existing equipment		Savings Relative to Standard Practice Equipment		EUL (years)	RUL (years)
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)		
EEM1: Jail Packaged HVAC Retrofit	78,098	12,700	14,786	2,071	15	0
EEM2: Jail EMS Upgrade	4,206	612	4,206	612	15	0
EEM3: Jail Boiler Retrofit	2,667	11,021	2,667	6,045	20	0
EEM4: Jail Lighting Retrofit	93,154	0	93,154	0	15	0
EEM5: County Buildings Lighting Retrofit	62,519	0	62,519	0	15	0

Source: DNV KEMA analysis

Table 47 provides life-cycle savings for the project relative to Baseline 1.

Table 47: Life-cycle Savings Relative to Baseline 1

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Natural Gas Energy Savings (Therms/yr)
1	2011	240,645	24,332
2	2012	240,645	24,332
3	2013	240,645	24,332
4	2014	240,645	24,332
5	2015	240,645	24,332
6	2016	240,645	24,332
7	2017	240,645	24,332
8	2018	240,645	24,332
9	2019	240,645	24,332
10	2020	240,645	24,332
11	2021	240,645	24,332
12	2022	240,645	24,332
13	2023	240,645	24,332
14	2024	240,645	24,332
15	2025	240,645	24,332
16	2026	2,667	11,021
17	2027	2,667	11,021
18	2028	2,667	11,021

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Natural Gas Energy Savings (Therms/yr)
19	2029	2,667	11,021
20	2030	2,667	11,021
21	2031	-	-
Life-cycle	Total	3,623,010 kWh	420,085 Therms

Source: DNV KEMA analysis

Table 48 provides life-cycle savings for the project relative to Baseline 2. Savings for the first year following the retrofit were calculated relative to the pre-existing equipment regardless of RUL. This approach was taken because the equipment would have presumably remained in place and operated for at least one year if the retrofit had not occurred.

Table 48: Life-cycle Savings Relative to Baseline 2

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Natural Gas Energy Savings (Therms/yr)
1	2011	240,645	24,332
2	2012	177,333	8,728
3	2013	177,333	8,728
4	2014	177,333	8,728
5	2015	177,333	8,728
6	2016	177,333	8,728
7	2017	177,333	8,728
8	2018	177,333	8,728
9	2019	177,333	8,728
10	2020	177,333	8,728
11	2021	177,333	8,728
12	2022	177,333	8,728
13	2023	177,333	8,728
14	2024	177,333	8,728
15	2025	177,333	8,728
16	2026	2,667	6,045
17	2027	2,667	6,045
18	2028	2,667	6,045
19	2029	2,667	6,045
20	2030	2,667	6,045
21	2031	-	-
Life-cycle	Total	2,736,642 kWh	176,749 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Merced, County of (CBG-09-021)

Site Summary

This project involved the relamping or replacement of 7,855 fixtures throughout four Merced County buildings. The following areas were included in the retrofit: administration building, public health building, adult correctional facility, and juvenile justice center. Typical operating hours for the administration building and public health center are 7 a.m. to 6 p.m. Monday through Friday with limited operation on the weekend for cleaning services. The correctional facilities operate 24 hours per day.

The implemented measures at Merced County buildings included a two-part lighting retrofit for both indoor (EEM1) and outdoor (EEM2) fixtures. Table 77 summarizes the ex post and ex ante savings estimates for this project.

Table 49: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 – Retrofit indoor light fixtures	196,184	43.9	0	178,256	30.5	0.0	91%	N/A
EEM2 – Retrofit outdoor light fixtures	197,046	N/A	0	270,294	0	0.0	137%	N/A
Total	393,230	43.9	0.0	448,550	30.5	0.0	114%	N/A

Source: DNV KEMA analysis

For EEM1, there was very little difference between the ex post savings and the savings estimated in the ex ante calculations. A sample of fixtures which included all major types and all buildings involved in the project revealed no discrepancies between the installed quantity or fixture type relative to the documents provided in the submitted calculations. Savings for this measure were reduced slightly after interviews with site personnel revealed that the annual hours of operation for the administration building and public health building were lower than those estimated in the original calculations submitted with the program documentation.

For EEM2, the site inspection revealed significant differences in fixture type and quantity between the savings calculations submitted in the program documents and the installed fixtures observed on-site. The final lighting survey provided to the evaluation team by site contacts 2

states that most of the installed fixtures were 2□ or 4□ T5HO fixtures, not induction lights as were originally specified in the savings calculations. This change adjustment was confirmed by the evaluation team on-site. Fixture wattages in the savings calculations spreadsheets were adjusted accordingly and modified first year savings are presented above.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For both lighting fixture retrofits, the baselines are identical.

For the indoor lighting retrofits (EEM1) and outdoor lighting retrofits (EEM2), DEER provides an EUL of 15 years.

Table 50: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline 1&2	6,728,250	30.5	0.0

Source: DNV KEMA analysis

Project Description

This project involved the relamping or replacement of 7,855 fixtures throughout four Merced County buildings. The following areas were included in the retrofit: administration building, public health building, adult detention center, and juvenile detention center.

Measure 1 – Retrofit Indoor Light Fixtures

EEM1 consisted of a complete lighting retrofit for all four buildings involved in the project. A room-by-room lighting survey was completed, which documented baseline as well as fixture types for all 7,855 fixtures replaced as part of this project. This survey was not included in the program documentation provided to the evaluation team; however, site contacts provided paper copies during the site visit. The vast majority of the line items involve the relamping of standard ballast factor 32 W T8 fixtures with 28 W T8 lamps.

Savings were calculated line-by-line using the following algorithm:

$$Annual\ savings\ (kWh) = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW = Baseline fixture wattage (kW)

BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Preretrofit annual hours of operation for usage group
PostRunHrs	= Postretrofit annual hours of operation for usage group (assumed to be the same as no measures involved the installation of occupancy sensors)

HVAC interactive effects were not accounted for in the ex ante savings estimates and therefore they are not included in the ex post analysis.

Project Evaluation

An ERS engineer visited the facility on February 7, 2012 to verify the installation of each measure and the hours of operation with site staff and ensure that the equipment specifications met those listed in the program documentation. The evaluation team inspected a large portion of the light fixtures installed as part of this project and verified the hours of operation with site personnel.

Measure 1 – Retrofit Indoor Light Fixtures

On-site verification activities confirmed that the lighting measure was installed as detailed in the lighting survey. A full lighting survey was provided on-site to the evaluation team. This survey listed room-by-room baseline and postinstallation fixture quantities and fixture types. ERS verified the installation of 1,107 fixtures in 57 rooms listed in the lighting survey. These rooms represented 15 percent of the total number of fixtures and 20 percent of the total measure savings.

Interviews with site contacts revealed that the annual hours of operation for both the administration building and the public health building were slightly less than those used in the simplified savings calculations included in the program documentation. The public health building operates from 7 a.m. to 6 p.m. on weekdays with an estimated 2 additional weekend hours for janitorial services. The administration building operates from 6 a.m. to 7 p.m. on weekdays with an estimated 3 additional weekend hours for janitorial services.

For each fixture type the evaluation team verified that the lamps and ballasts installed matched those listed in the lighting survey. The evaluation team found no major discrepancies affecting the total project savings.

Figure 20 and Figure 21 below show sample light fixtures and ballasts surveyed as part of the inspection process.

Figure 20: Adult Detention – Sample Sleeping Room Fixtures

Photo Credit: DNV KEMA

Figure 21: Administration Building - Standard Ballast Factor Fixture

Photo Credit: DNV KEMA

Measure 2 – Retrofit Outdoor Light Fixtures

On-site verification activities confirmed that the installed fixtures were not the induction type detailed in the savings calculations included in the program documentation. The evaluation team found the lighting survey provided by the site was accurate as it listed two-, three-, and four-lamp T5HO fixtures as well as CFL units. The lighting survey listed outdoor space types, baseline and postinstallation fixture quantities, and fixture types. ERS verified the installation of 130 fixtures in 13 spaces listed in the lighting survey. These spaces represented 31 percent of the total number of fixtures and 34 percent of the total measure savings.

For each fixture type the evaluation team verified that the lamps matched those listed in the lighting survey. The evaluation team recalculated savings line-by-line for this measure using the fixture types listed in the lighting survey. The updated ex ante values provided in the database update are used to estimate the realization rate in Table 49.

Figure 22 and Figure 23 below show sample light fixtures surveyed as part of the inspection process.

Figure 22: Administration Building - 2 Three Lamp T5HO Fixture

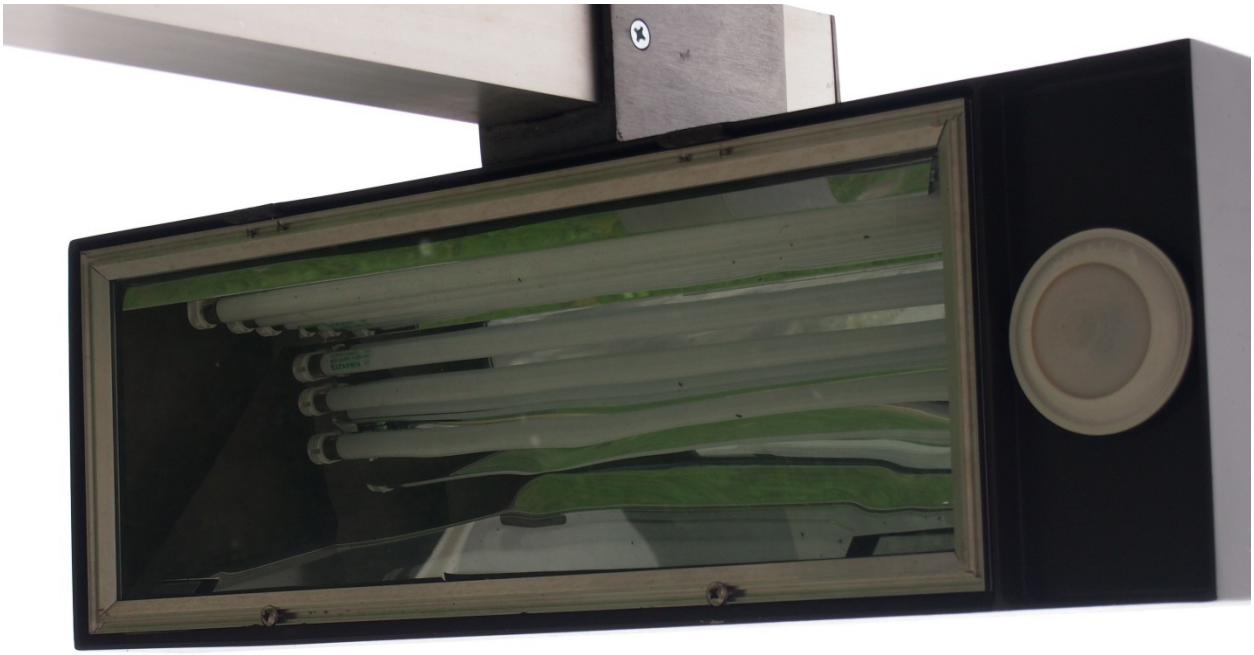


Photo Credit: DNV KEMA

Figure 23: Public Health Building – 4' Three Lamp T5HO Fixture

Photo Credit: DNV KEMA

Savings Results

Taking into account both EEMs, the Merced County project resulted in 448,550 kWh in annual gross energy savings. Peak demand savings of 30.5 kW were estimated using coincident demand factors from DEER 2011. A breakdown of savings by individual measure is presented in Table 49 at the beginning of this report. The ex ante savings estimates, which were acquired from the program's monthly status reports, are also provided as a point of reference.

Discussion

Measure 1 - Retrofit Indoor Light Fixtures

On-site verification activities confirmed that the lighting measure was installed as detailed in the program documentation. The evaluation team verified the installation of 1,107 fixtures in 57 rooms listed in the lighting survey. These rooms represented 15 percent of the total number of fixtures and 20 percent of the total measure savings. The annual hours of operation for both the administration building and the public health building were less than those estimated in the ex ante savings calculations. This change resulted in a 10 percent reduction in annual savings.

Measure 2 – Retrofit Outdoor Light Fixtures

On-site verification activities confirmed that the lighting measure was not installed as detailed in the ex ante savings calculations. The evaluation team recalculated the savings line-by-line using the lighting survey provided on-site. These results are compared with the revised ex ante estimates provided in the tracking data on 9/17/12.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1). The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the EEM implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 52 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 51: Life Cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	448,550	30.5	0.0
2	2012	448,550	30.5	0.0
3	2013	448,550	30.5	0.0
4	2014	448,550	30.5	0.0
5	2015	448,550	30.5	0.0
6	2016	448,550	30.5	0.0
7	2017	448,550	30.5	0.0
8	2018	448,550	30.5	0.0
9	2019	448,550	30.5	0.0
10	2020	448,550	30.5	0.0
11	2021	448,550	30.5	0.0
12	2022	448,550	30.5	0.0
13	2023	448,550	30.5	0.0
14	2024	448,550	30.5	0.0
15	2025	448,550	30.5	0.0
Total		6,728,250 kWh		0.0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Mono, County of (CBG-09-026-A)

Site Summary

Mono County completed a retrofit project involving HVAC controls and lighting upgrades affecting two county Annex buildings. In Annex 1, new outdoor air economizer actuators were installed, new zone damper actuators were installed in the building's six zones, and new sensors and Energy Management System (EMS) controls were implemented to allow nighttime and unoccupied setback. In Annex 2, new zone dampers and actuators were installed to increase the number of control zones in the building from two (one per air handler) to four (two per air handler), new thermostats were installed, and EMS controls were implemented to allow nighttime and unoccupied setback.

In addition to the HVAC measures, Annex 1 was retrofit with LED exit lights and occupancy sensors. CFL and T8 measures were also planned, but the scope of the project changed and these measures were not ultimately implemented.

Table 52 below summarizes the energy savings achieved by the Mono County project.

Table 53: Energy Savings Summary

Measure	Ex Ante		Ex Post (Baseline 1)		Realization Rate	
	Electric energy (kWh)	Gas Energy (Therms)	Electric energy (kWh)	Gas Energy (Therms)	Electric	Gas
Annex 1 – HVAC Controls Retrofit	15,439	58	3,311	700	21%	1,214%
Annex 2 - HVAC Controls Retrofit	27,157	55	8,253	799	30%	1,455%
LED Exit Signs	1,249	0	858	0	69%	N/A
Lighting Controls	676	0	676	0	100%	N/A
Total	44,521	113	13,098	1,499	29%	1,332%

Source: DNV KEMA analysis

Life-cycle savings were calculated for each EEM based on DEER EUL values. Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment is exceeded

Table 54: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Natural Gas Energy Savings (Therms)
Baseline 1	192,596	22,485
Baseline 2	192,596	22,485

Source: DNV KEMA analysis

Project Description

Mono County completed HVAC controls retrofits in their two County Annex Buildings in Bridgeport, CA. In Annex 1, the following modifications were implemented:

- Six new DDC zone dampers were installed to control conditioned airflow to the building's six zones (three per air handler).
- New zone temperature sensors were installed in each zone to provide control for the new dampers.
- Two new actuators and mixed air temperature sensors were installed to allow for control of the existing economizers (one per AHU).
- Honeywell Excel 5000 controllers and time clock controls were installed to allow zone and economizer damper control, as well as implementation of nighttime and holiday setback temperature set points.

In Annex 2, the following upgrades were implemented:

- New DDC control dampers were installed to convert the two existing single zone AHUs into dual zone AHUs.
- New zonal, supply, and return air temperature sensors were installed to allow implementation of zonal temperature control.
- New three-way valves were installed to control hot water flow to the building's two air handlers (previously there was no flow control since the pre-existing valves had failed).

- Honeywell Excel 5000 controllers and time clock controls were installed to allow zone and economizer damper control, as well as implementation of nighttime and holiday setback temperature set points.

In addition to the control measures, seven incandescent exit signs were replaced with LED exit signs, and eight occupancy sensors were installed to control 26 CFLs and six 2-lamp 4' T8 fixtures in Annex 1.

Ex ante Savings

In the feasibility study, ex ante savings for the control projects in Annex 1 and Annex 2 were calculated as a fraction of annual billed energy use in 2009. The retrofits were projected to reduce electric energy use by 14 percent in both buildings, and reduce propane use by 1 percent.

The electric savings factor of 14 percent was estimated based on vague statements from ASHRAE and the Building Owners and Managers Institute International (BOMI) regarding the savings potential of HVAC control improvements. The source of the 1 percent propane savings factor cited previously is unknown. In any case, this savings factor approach was simplistic.

For the exit sign measure, savings were calculated based on the wattage differential between the installed and pre-existing cases and the estimated hours of operation. Since the motion sensors were not included in the initial scope, DNV KEMA calculated their ex ante savings using the methodology described in Project Evaluation section.

Project Evaluation

The evaluation team visited the project site to verify equipment installation and gather information regarding pre-existing and current operations from site contacts. During the site visit, installation of the proposed zone dampers, economizer actuators, temperature sensors, and Honeywell control equipment was verified in Annex 1. The site contacts stated that prior to the retrofit, facility personnel manually modulated the outside air supply by physically moving the existing dampers. Similarly, air supply to various zones was manually modulated using the existing dampers. Prior to the retrofit, the heating system operated 24/7 with set points in the range of 70 F to 73 F.

As a result of the Annex 1 retrofit, the building's six individual zones are now more tightly temperature controlled and the building uses outdoor economizer air for cooling. Additionally, the heating set point resets to 60 F outside of a warm-up period and normal business hours (5 a.m. to 6 p.m., Monday through Friday). During normal operating hours, the zonal heating set points, which are locally controlled by occupants, remain in the 70 F to 73 F range. During January and February, the building does not use the setback schedule due to excessively cold temperatures. Annex 1 does not have mechanical cooling, and therefore does not have any cooling set points.

In Annex 2, new zone dampers, temperature sensors, hot water three way valves, and Honeywell controls were found installed as proposed. Prior to installing the new zone dampers, the building consisted of only two zones according to the site contact—one for the upstairs

system and one for the downstairs system—leading to localized pockets of overheating and overcooling. The building now contains two upstairs and two downstairs zones. Instead of running the heating and cooling systems 24/7, the building now operates on an identical setback schedule to Annex 1. Occupied heating set points are typically maintained in the 70 F to 73 F range, while occupied cooling set points are highly variable, but generally remain between 70 F and 76 F. Outside of occupied hours, the heating and cooling set points are setback to 60 F and 85 F respectively. As with Annex 1, the building does not utilize its setback schedule during January and February because of very cold weather.

The implementation of the lighting portion of the project was not consistent with the original scope. In total, seven incandescent exit signs were replaced with LED exit signs, and eight occupancy sensors were installed to control 26 CFLs and six 2-lamp 4' T8 fixtures in Annex 1.

Savings for the controls measures in Annex 1 and Annex 2 were assessed using eQUEST simulation models built for the evaluation. In addition to gathering measure specific data during the site visit, building plans were collected for both Annex 1 and Annex 2 to allow simulation modeling.

Savings in Annex 1 were assessed by generating a baseline model that ran its heating systems 24/7, and an installed case model that ran its heating systems in accordance with the building's present setback schedule. During the nighttime setback period, fans were scheduled to remain off unless required to meet zonal set points. Differential temperature economizer controls were additionally added to the installed case model.

Similarly, baseline and installed case eQUEST models were constructed for Annex 2. The baseline building was modeled with one zone per system and no nighttime setback. The installed case building was modeled with two zones per floor and the newly implemented setback schedule. During the nighttime setback period, fans were scheduled to remain off unless required to meet zonal set points. No model modifications were made to represent the effect of the new three way valves. While these valves yield better flow control through the AHUs, they do not necessarily save energy since water flow is simply diverted around the AHUs. Irrespective of the new three way valves, the building's hot water pumps still operate at constant speed.

Savings were determined by simulating the base case and installed case models with a CZ2 (California Climate Zones Revision 2) weather file for California climate zone 16 and then taking the difference between two scenariosCZ2 data were used instead of TMY3 data because a TMY3 file does not exist for Bridgeport, CA.

Lighting savings were calculated using a spreadsheet approach. Savings for all replaced exit signs were calculated by multiplying the pre and postretrofit wattage differential by the estimated operating hours (8,760 for exit signs). Savings for lights controlled by new occupancy sensors in hallways and restrooms were calculated by assuming a 30 percent reduction in operating hours during the postretrofit period.

Savings Results

Relative to the pre-existing conditions, the project saved 13,098 kWh and 1,499 therms, yielding 29 percent and 1,332 percent realization rates for electricity and gas respectively. Since the HVAC measures consisted of only controls upgrades, and the lighting measure consisted of a combination of controls and otherwise Title 24 compliant pre-existing equipment, Baselines 1 and 2 produced identical results.

Discussion

Ex post electric energy savings differ significantly from the ex ante estimate. This result is understandable given that the ex ante calculation relied on a scale factor of existing energy use to estimate savings. In Annex 1, little electric energy savings should have been expected since the installed measures primarily function to reduce the heating load in the building via night time set back controls. The outdoor air economizer measure increases occupant comfort, but does little to save energy since it is not functioning in lieu of mechanical cooling, which the building does not have. Similarly, the damper control measure helps improve zone control and thereby increases occupant comfort, but the building's constant speed supply fans still operate regardless. The dampers therefore do not provide electric savings. Electric savings are only realized at night when the air handler fan turns off during setback operation.

Many of the same considerations apply to Annex 2 that apply to Annex 1. While increasing the number of zones in the building improves occupant comfort, it did not necessarily yield savings during normal business hours so long as the same set points are employed.

The Annex 2 project did yield a slightly higher electric realization rate than the Annex 1 project largely because the building does have mechanical cooling. As a result, reduced cooling operation during the setback period generates electric savings beyond what would be achieved simply from running air handler fans for fewer hours. Nonetheless, additional cooling savings are minimal because Bridgeport has relatively mild summers and requires little cooling outside of normal business hours, excepting during weekend days.

Both the Annex 1 and Annex 2 control projects exceeded the gas savings projections included in the feasibility study. Given that Bridgeport has bitterly cold nights, substantial gas savings are expected from implementing setback schedules.

Lighting savings did not meet expectations because fewer exit signs were replaced than expected.

Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This

baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

Table 55 below provides the annual energy savings estimates that fed into the life-cycle savings calculations, as well as the EULs for the installed measures.

Table 55: Values Used in Life-cycle Savings Calculations

Measure	Early Replacement		Expected Replacement		EUL (years)	RUL (years)
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)		
Annex 1 – HVAC Controls Retrofit	3,311	700	3,311	700	15	0
Annex 2 - HVAC Controls Retrofit	8,253	799	8,253	799	15	0
LED Exit Signs	858	0	858	0	16	0
Lighting Controls	676	0	676	0	8	0

Source: DNV KEMA analysis

Table 56 provides life-cycle savings for the project relative to Baseline 1 and Baseline 2.

Table 56: Life-cycle Savings Relative to Baseline 1 and Baseline 2

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Natural Gas Energy Savings (Therms/yr)
1	2011	13,098	1,499
2	2012	13,098	1,499
3	2013	13,098	1,499
4	2014	13,098	1,499
5	2015	13,098	1,499
6	2016	13,098	1,499
7	2017	13,098	1,499
8	2018	13,098	1,499
9	2019	12,422	1,499
10	2020	12,422	1,499
11	2021	12,422	1,499
12	2022	12,422	1,499
13	2023	12,422	1,499
14	2024	12,422	1,499
15	2025	12,422	1,499
16	2026	858	0
17	2027	0	0
Life-cycle	Total	192,596 kWh	22,485 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

San Marino, City of (CBG-09-027)

Site Summary

The City of San Marino applied for EECBG funds for one EEM: replacement of aging residential style split HVAC systems serving the San Marino City Hall, Police Department, Emergency Operations Center, Computer Room, Fire Department, Gymnasium, and PW Department facilities. The replaced equipment includes 11 furnace/air handler units, 13 condensing units, 13 evaporator coil units, one heat pump unit, and one fan coil unit.

DNV KEMA performed site visits at all of the city facilities that received EECBG funded energy efficiency retrofits. During the site visits, DNV KEMA verified the quantity, manufacturers, and model numbers of all the installed HVAC equipment. DNV KEMA also gathered HVAC operational schedules and set point temperatures for all the replaced systems.

Spreadsheet analysis was used to estimate energy savings for all measures using a combination of site findings and literature reviews. The analysis yielded an overall annual electric energy savings of 54.1 percent and natural gas savings of 101.7 percent when compared to ex ante estimates. The energy and power savings by measure are provided in Table 57.

Table 57: Energy Savings Summary by Measure Category

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
HVAC	45,936	63.8	608	24,862	32.8	618	54.1%	101.7%
Total	45,936	63.8	608	24,862	32.8	618	54.1%	101.7%

Source: DNV KEMA analysis

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses *minimally code-compliant* conditions or *standard practice* as the baseline once the RUL of the pre-existing equipment is exceeded.

The overall results from Table 57 yields a lifecycle energy savings of 372,915 kWh, lifecycle demand savings of 492 kW-years, and lifecycle natural gas energy savings of 9,270 therms when considering the buildings' existing conditions (Baseline 1). Using a Baseline 2, which accounts for the RUL of the pre-existing equipment, the lifecycle savings total 51,461 kWh, 81.6 kW-years, and 9,270 therms as shown in Table 58.

Table 58: Ex Post Lifecycle Savings Totals

Baseline Type	Electrical Energy Savings (kWh)	Electric Demand (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1	372,915	492	9,270
Baseline 2	51,461	81.6	9,270

Source: DNV KEMA analysis

Project Description

Measure 1: Split HVAC Systems

This measure involved the replacement of major components of the city's split HVAC systems. These retrofits, grouped by facility, are listed below:

- Police Department
  - Three four-ton condensing units and evaporator coils
  - Three 80 kBTU/hr, 1600 cubic feet per minute (CFM) furnace air handlers
- Emergency Operations Center
  - One two-ton condensing unit and evaporator coil
- Computer Room
  - One two-ton condensing unit and evaporator coil
- Fire Department
  - Two four-ton condensing units and evaporator coils
  - Two 80 kBTU/hr, 1600 CFM furnace air handlers
  - One three-ton condensing unit and evaporator coils
  - One 60 kBTU/hr, 1200 CFM furnace air handler
- PW Department
  - One three-ton condensing unit and evaporator coil
  - One 60 kBTU/hr, 1200 CFM furnace air handler
- Gymnasium
  - One three-ton reversible heat pump
  - One three-ton, 1200 CFM fan coil unit
- City Hall
  - One three and a half-ton condensing unit

- Three three-ton condensing units
- Four three-ton evaporator coils
- Four 60 kBTU/hr, 1200 CFM furnace air handlers

Ex Ante Savings

Measure 1: Split HVAC Systems

The ex ante savings calculations for the condensing AC units, heat pumps, and furnace/air handlers were performed using simplified spreadsheet based engineering calculations that utilized historical billing data.

According to the site contact, the ex ante kWh electrical energy savings calculation was based upon the equipment manufacturer's suggested savings of 30 percent of current AC energy consumption. The annual AC energy was estimated as 50 percent of the average of all facility kWh use. This average kWh energy consumption was calculated from historical billing data for the following periods: June 2010, July 2010, August 2010, January 2011, February 2011, and March 2011. The total kWh consumed for this 6 month period is 153,120 kWh making the monthly average 25,520 kWh per month and the assumed AC usage 12,760 kWh per month. Then, employing the assumed efficiency gains of 30 percent energy savings, the monthly energy savings is calculated to be 3,828 kWh. Finally, annual kWh saving is computed by multiplying the monthly kWh savings value by 12 months to arrive at 45,936 kWh. This calculation method is represented by the equation below:

$$Annual\ kWh\ savings = kWh_{monthly\ avg} \times 50\%_{AC\ Usage} \times 30\%_{energy\ savings} \times 12\ \frac{months}{year}$$

The ex ante kW electrical demand savings value is calculated by dividing the monthly kWh savings by the monthly hours of operation for the police/ fire station to arrive at a monthly kW value. The monthly hours of operation are calculated to be 720 hours assuming that the facility operates 168 hours per week for 4.3 weeks per month. The savings of 3,828 kWh per month is divided by the 720 operational hours per month to arrive at 5.32 kW per month. Annual kW savings of 63.8 is calculated by multiplying the monthly kW demand savings by 12. This calculation method is represented by the equation below:

$$Annual\ kWsavings = \frac{3{,}828\ kWh_{\ monthly\ savings}}{720\ monthly\ hours\ of\ operation} \times 12\frac{months}{year}$$

The ex ante therm savings calculation uses a similar method as the kWh calculation, relying on a suggested savings of 25 percent of current therm energy consumption. The annual therm usage was estimated by averaging therm usage for the months of October 2010, November 2010, December 2010, January 2011, February 2011, and March 2011, and then multiplying this average by 12 to produce an average 12 month consumption value. This annual consumption value is then multiplied by the assumed 25 percent energy savings to arrive at an estimated 608 annual therm savings. This calculation method is represented by the equation below:

$$Annual\ therm\ savings = 202.5\ therms_{monthly\ avg} \times 12\frac{months}{year} \times 25\%_{energy\ savings}$$

Project Evaluation

A DNV KEMA field engineer visited the project sites on June 7th, 2012 to verify the measure installations and gather data on equipment model numbers, quantities, and HVAC control schemes. Table 59 summarizes the results of the installation verification.

Table 59. Verification Summary

Site	Equipment	Reported	Verified	Site Notes
Police Department	Air Handler/ Furnace	3	3	Model Number: T9MPX080J16A2
Police Department	Condensing Unit	3	3	Model Number: N4A348GHB200
Police Department	Evaporator Coil	3	3	Model Number: PE33648C227B2520AP
Emergency Operations Center	Condensing Unit	1	1	Model Number: NXA624GKA100
Emergency Operations Center	Evaporator Coil	1	1	Model Number: PE24636C192B2020AP
Computer Room	Condensing Unit	1	1	Model Number: NXA624GKA100
Computer Room	Evaporator Coil	1	1	Model Number: PE24636C192B2020AP
Fire Department	Air Handler/ Furnace	2	2	Model Number: T9MPX080J16A2
Fire Department	Air Handler/ Furnace	1	1	Model Number: T9MPX060F12A2
Fire Department	Condensing Unit	2	2	Model Number: N4A348GHB200
Fire Department	Condensing Unit	1	1	Model Number: N4A336GHB200
Fire Department	Evaporator Coil	2	2	Model Number: PE33648C227B2520AP
Fire Department	Evaporator Coil	1	1	Model Number: PE24636C192B2020AP
PW Department	Air Handler/ Furnace	1	1	Model Number: T9MPX060F12A2
PW Department	Condensing Unit	1	1	Model Number: NXA636GKA100
PW Department	Evaporator Coil	1	1	Model Number: PE24636C192B2020AP

Site	Equipment	Reported	Verified	Site Notes
Gymnasium	Split Heat Pump Unit	1	1	Model Number: NXH536GKA100
Gymnasium	Heat Pump Fan Coil	1	1	Model Number: FXM4X3600A
City Hall	Air Handler/ Furnace	3	4	Model Number: T9MPX060F12A2
City Hall	Air Handler/ Furnace	1	0	Model Number: T9MPX080J16A2. Smaller 60 kBTU/hr, 1200 CFM unit installed (see above entry).
City Hall	Condensing Unit	3	3	Model Number: NXA636GKA100
City Hall	Condensing Unit	1	1	Model Number: NXA642GKA100
City Hall	Evaporator Coil	4	4	Model Number: PE24636C192B2020AP

Source: DNV KEMA analysis

Measure 1: Split HVAC Systems

The ex post HVAC measure savings analysis was based on a five-degree (˚F), weather bin analysis spreadsheet method that utilized the local TMY3 weather data set, operating schedules and set point temperatures to derive heating and cooling loads. The bin analysis method assumed the HVAC equipment was properly sized to meet heating and cooling loads of buildings and the heating and cooling loads are ambient-temperature driven and have a near-linear relationship with ambient temperature.

During the site visit, DNV KEMA verified the installations of the HVAC equipment, acquired model numbers and capacity nameplate information, and gathered operational schedules and set point temperatures from the site contact the for the cooling and heating equipment. Subsequently, DNV KEMA gathered heating and cooling efficiency values for the condensing units, heat pumps, and furnaces as well as TMY3 hourly, ambient dry-bulb temperature data from the nearby Burbank-Glendale airport.

As per the set point temperature information provided by the site contact, the building cooling load occurs between the 70-65°F ambient temperature bin and the 105-110°F bin; the building heating load occurs between the ≤30°F bin and the 70-65°F bin. The bin analysis model considered the hours of operation along with flags set to indicate heating and cooling (June – September) months.

The following information on schedules, capacity, and efficiency values were used to determine measure savings:

- Police Department

    - Two four-ton condensing units and evaporator coils , Two 80 kBTU/hr, 1600 cubic feet per minute (CFM) furnace air handlers
        - Operate 8,760 hours per year
        - Cooling/heating set point temperatures: 75/70
        - 13 SEER, 95 AFUE
    - One four-ton condensing unit and evaporator coil, 80 kBTU/hr, one 1600 cubic feet per minute (CFM) furnace air handler
        - Operates 8 a.m.to 5 p.m., Monday through Thursday
        - Cooling/heating set point temperatures: 75/70
        - 13 SEER, 95 AFUE
- Emergency Operations Center
    - One two-ton condensing unit and evaporator coil
        - Operates 9 a.m.to 5 p.m., Wednesdays
        - Cooling set point temperature: 75
        - 16 SEER
- Computer Room
    - One two-ton condensing units and evaporator coil
        - Operates 8,760 hours per year
        - Cooling set point temperature: 74
        - 16 SEER
- Fire Department
    - Two four-ton condensing units and evaporator coils, two 80 kBTU/hr, 1600 CFM furnace air handlers
        - Operate 8,760 hours per year
        - Cooling/heating set point temperatures: 75/70
        - 13 SEER, 95 AFUE
    - One three-ton condensing unit and evaporator coil, One 60 kBTU/hr, 1200 CFM furnace air handler
        - Operates 7 a.m.to 5 p.m., Monday through Thursday
        - Cooling/heating set point temperatures: 75/70
        - 13 SEER, 95 AFUE
- PW Department
    - One three-ton condensing unit and evaporator coil, One 60 kBTU/hr, 1200 CFM furnace air handler
        - Operates 6:00 a.m.to 4 p.m., Monday through Friday
        - Cooling/heating set point temperatures: 75/70
        - 16 SEER, 95 AFUE
- Gymnasium

- One three-ton reversible heat pump, one three-ton, 1200 CFM fan coil unit
  - Operates 6 a.m.to 10 p.m., Monday through Sunday
  - Cooling/ heating set point temperatures: 78/ 68
  - 13.5 SEER, 8.2 HSPF
- City Hall
  - One three and a half-ton condensing unit, three three-ton condensing units , four three-ton evaporator coils, and four 60 kBTU/hr, 1200 CFM furnace air handlers
    - Operate 7 a.m.to 6 p.m., Monday through Thursday
    - Cooling/heating set point temperatures: 78/68
    - 16 SEER, 95 AFUE

For Baseline 1 all replacement condensing units were compared against 10 SEER units adjusted to 8 SEER to account for age-related performance degradation. The standard age related performance degradation factor of 10 percent was doubled to 20 percent due to the age of the equipment and the information provided by the site contact indicating that the equipment had significant problems. For Baseline 2 all replacement condensing units were calculated against the minimally code compliant 13 SEER. For Baseline 1 all existing air handling units were assumed to have fan motor efficiencies twenty percent below the replacement units, while Baseline 2 conditions assumed the normal replacement fan motors would exhibit the same efficiency as the installed air handling units. For both Baseline 1 and 2, all replacement furnace air handler units were compared against 80 AFUE. For the heat pump equipment, the replacement unit was compared against a 6.56 Heating Seasonal Performance Factor (HSPF) for Baseline 1 conditions, and 6.8 HSPF for Baseline 2 conditions.

This analysis yielded the first-year annual energy savings of 24,861 kWh and 618 therms.

Electric demand savings for the cooling equipment were calculated at full-load cooling capacity by taking the difference between the energy consumption of the high-efficiency replacement units and, for Baseline 1 conditions, that of the low-efficiency existing units and, for the baseline 2 conditions, that of normal-efficiency replacement units. The first-year electric demand savings yielded by this analysis was 32.8 kW for all the units under Baseline 1 conditions.

Savings Results and Discussion

The project saved 24,861 kWh of electric energy and 618 therms of natural gas energy in the first year and represents a realization rate of 54.1 percent for electric energy and 102 percent for therms energy when compared to the ex ante estimated savings. Furthermore, the project reduced summer on-peak demand by 32.8 kW in the first year. Summer on-peak demand savings was not claimed ex ante.

Measure 1: Split HVAC Systems

Sources of uncertainty regarding these HVAC calculations included the assumed level of degradation of the existing equipment, relying on limited billing data to calibrate pre-retrofit

modeled energy use, and the assumptions inherent in the bin analysis method regarding equipment sizing and building cooling and heating loads being primarily weather dependent.

DNV KEMA's lower ex post savings estimate for electric energy kWh (54.1 percent) is primarily due to the fact that the ex ante savings calculations were based on a number of assumptions and simplifications that overestimate the existing air-conditioning energy consumption. These assumptions include:

- Over estimation of the percentage of air-conditioning electrical energy consumption to total site electrical energy consumption
- Electricity consumption values from heating months of January, February, and March are used for calculation of cooling energy consumption
- Attributing air-conditioning saving to 12 months of the year instead of just cooling months.

The ex post savings calculations produce an electrical energy savings of 36 percent more than the ex post calculated pre-retrofit HVAC electricity consumption, which is 6 percent greater than the ex ante assumed 30 percent savings. A major discrepancy between ex post and ex ante calculations is the difference between assumed and calculated air-conditioning electrical energy consumption to total site electrical energy consumption. The ex ante method assumes 50 percent of total consumption is attributable to the HVAC systems, while the ex post calculation produces a value of 16 percent HVAC energy consumption relative to total site electrical energy consumption.

DNV KEMA's slightly higher ex post savings estimate for natural gas energy (102 percent) is primarily due to the one 60 kBTU/hr air handler-furnace unit was installed at the City Hall facility instead of an 80 kBTU/hr unit. This unit was modeled as replacing a like 60 kBTU/hr furnace.

DNV KEMA's lower ex post savings estimate for demand reduction (51.4 percent) is due to the fact that the ex ante calculation method for demand savings is incorrect. The method computes the monthly average demand savings over the year from the ex ante monthly electrical energy savings, instead of calculating the load reduction during summer on-peak period when the AC units will likely be operating at a higher than average load level. This monthly average load reduction is then multiplied by 12 to produce an annual demand savings. Further exaggerating the ex ante demand savings value is that fact that the monthly electrical energy savings, on which the ex ante demand savings value is calculated, is likely too large.

Ex Post Lifecycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of

the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

Table 60 displays the annual kWh, kW, and therm savings values used to calculate the Baseline 1 and Baseline 2 lifecycle savings. Table 60 also lists the effective and remaining useful lives of each measure that were used in conjunction with the first year energy and power savings values. Table 61 presents the electrical energy, electrical demand, and natural gas energy savings according to Baseline 1 conditions for each year the measure is in place up to the end of the measure's EUL. Table 62 presents the yearly lifecycle savings values according to Baseline 2 conditions.

Table 60: Values Used in Ex Post Lifecycle Savings Calculations

Measure	Early Replacement			Expected Replacement			EUL (years)	RUL (years)
	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)		
Measure 1: Split HVAC Systems	24,861	32.80	618	1,900	3.49	618	15	1
Total	24,861	32.80	618	1,900	3.49	618	-	-

Source: DNV KEMA analysis

Table 61: Baseline 1 Lifecycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW-years)	Natural Gas Energy Savings (Therms/yr)
1	2012	24,861	32.78	618
2	2013	24,861	32.78	618
3	2014	24,861	32.78	618
4	2015	24,861	32.78	618
5	2016	24,861	32.78	618
6	2017	24,861	32.78	618
7	2018	24,861	32.78	618
8	2019	24,861	32.78	618
9	2020	24,861	32.78	618
10	2021	24,861	32.78	618
11	2022	24,861	32.78	618
12	2023	24,861	32.78	618
13	2024	24,861	32.78	618

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW-years)	Natural Gas Energy Savings (Therms/yr)
14	2025	24,861	32.78	618
15	2026	24,861	32.78	618
Lifecycle Total		372,915 kWh	491.7 kW-years	9,270 Therms

Source: DNV KEMA analysis

Table 62: Baseline 2 Lifecycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW-years)	Natural Gas Energy Savings (Therms/yr)
1	2012	24,861	32.80	618
2	2013	1,900	3.49	618
3	2014	1,900	3.49	618
4	2015	1,900	3.49	618
5	2016	1,900	3.49	618
6	2017	1,900	3.49	618
7	2018	1,900	3.49	618
8	2019	1,900	3.49	618
9	2020	1,900	3.49	618
10	2021	1,900	3.49	618
11	2022	1,900	3.49	618
12	2023	1,900	3.49	618
13	2024	1,900	3.49	618
14	2025	1,900	3.49	618
15	2026	1,900	3.49	618
Lifecycle Total		51,461 kWh	81.6 kW-years	9,270 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

El Paso de Robles, City of (CBG-09-028)

Site Summary

This streetlight project consisted of replacing 300 MH fixtures (100 W) with 300 Induction fixtures (48 W). The application originally claimed 300 fixtures, but grew to 313 fixtures as the project progressed. Annual operating hours for all fixtures (photocell controlled) were assumed to be 4,380 as provided by the city's calculations. Installation verification was performed by randomly sampling fixtures from the city's installation tracking spreadsheet. A total of 215 fixtures were included in the verification sample. Of the 215 fixtures, all fixtures were found to be retrofitted, but the wattages could not be confirmed because there was no bulb access. No modifications of the city's tracking quantities or fixture nominal wattages were made based on the verification sample. The difference between the ex ante and ex post values are based on the difference between nominal wattages and functional wattages. The city's calculation considered the nominal wattage only, which underestimated the savings. The MH lights had a higher functional wattage, resulting in more savings.

Table 63: Savings and Realization Rate

Ex Ante Savings	Ex Post Savings	Realization Rate
63,328 kWh	89,111 kWh	130.4%

Source: DNV KEMA analysis

Table 64: Tracking Spreadsheet Retrofit Claims

Pre-Existing Fixtures			Installed Fixtures			
Type	Nominal Wattage	Functional Wattage	Type	Nominal Wattage	Functional Wattage	Fixture Count
MH	100	118	Induction	48	53	313

Source: DNV KEMA analysis

Table 65: Verified Sample Findings

Pre-Existing Fixtures		Installed Fixtures				
Type	Nominal Wattage	Type	Nominal Wattage	Verified Fixture Count	% of Verification Sample Properly Installed	Average Functional Wattage of Fixtures with Discrepancies
MH	100	Induction	48	215	100%	-
Total					100%	

Source: DNV KEMA analysis

Table 66: Verification Revised Fixture Table

Pre-Existing Fixtures			Installed Fixtures					
Type	Nominal Wattage	Functional Wattage	Type	Nominal Wattage	Revised Functional Wattage Based on Verification	Fixture Count	Verified Demand Reduction (kW)	Verified Energy Savings (kWh)
MH	100	118	Induction	48	53	313	20.35	89,111
Total							20.35	89,111

Source: DNV KEMA analysis

Figure 24: Verification Sample Area Map

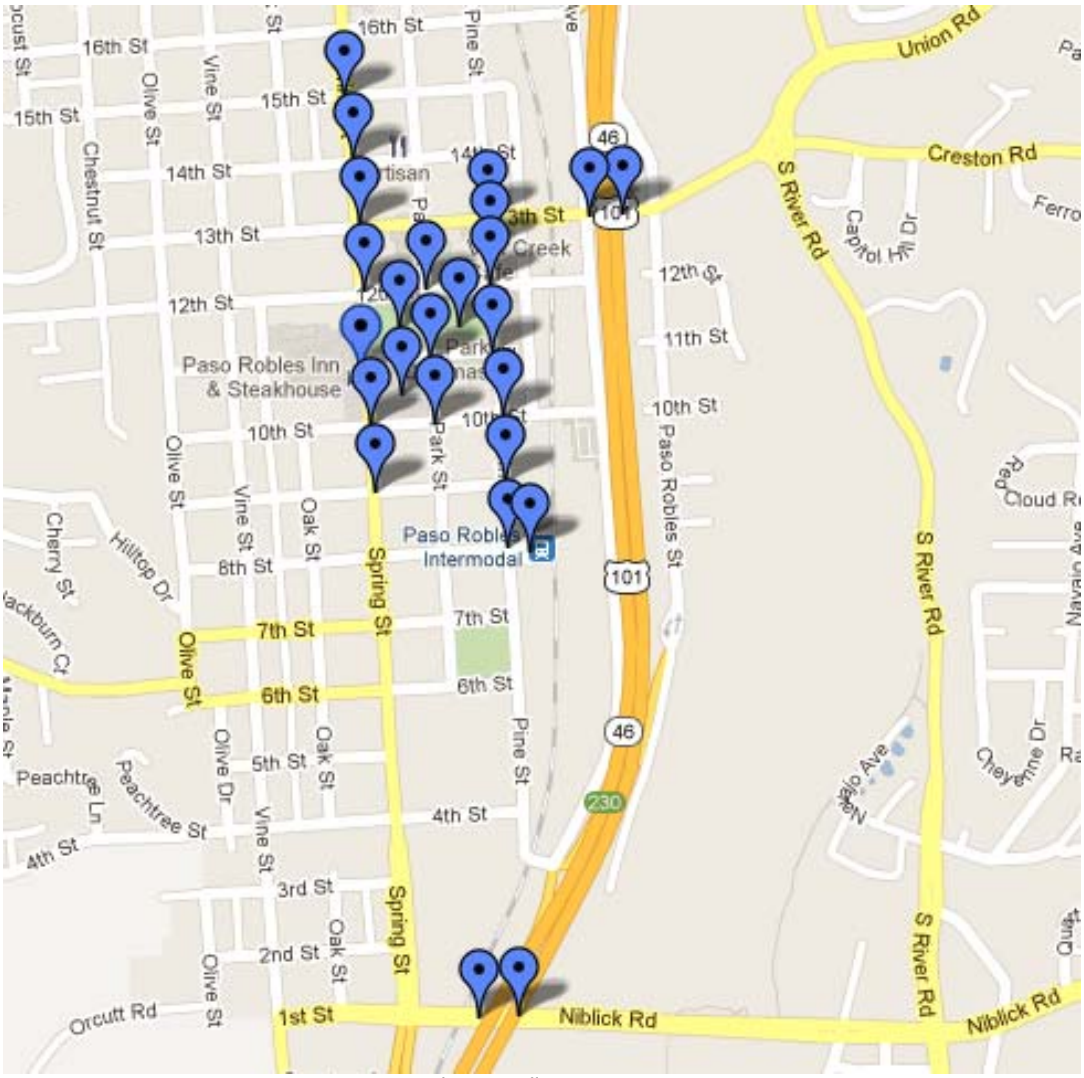


Photo Credit: DNV KEMA

Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EULof the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable. According to the decision maker survey completed with the site contact , the

pre-existing streetlighting was installed 10-30 years ago depending on maintenance and replacement schedules. The typical EUL for streetlighting is 15 years.

The tables below provide life-cycle savings for the project relative to Baseline 1 on a year-by-year basis through the EUL of the longest lived measure. Under this baseline, energy savings were presumed to occur relative to the pre-existing equipment for the duration of each measure's life. For this project, the life-cycle savings estimates relative to Baseline 2 (dual baseline) are the same as the life-cycle savings relative to Baseline 1.

Table 67: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	89,111	20.3	0
2	2012	89,111	20.3	0
3	2013	89,111	20.3	0
4	2014	89,111	20.3	0
5	2015	89,111	20.3	0
6	2016	89,111	20.3	0
7	2017	89,111	20.3	0
8	2018	89,111	20.3	0
9	2019	89,111	20.3	0
10	2020	89,111	20.3	0
11	2021	89,111	20.3	0
12	2022	89,111	20.3	0
13	2023	89,111	20.3	0
14	2024	89,111	20.3	0
15	2025	89,111	20.3	0
16	2026	0	0	0
Total		1,336,665 kWh	305 kW-years	0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Foster City, City of (CBG-09-032)

Site Summary

Table 68: Savings and Realization Rate

Ex Ante Savings	Ex Post Savings	Realization Rate	Life-cycle Savings
149,397 kWh	149,397 kWh	100%	3,645,297 kWh

Source: DNV KEMA analysis

This streetlight project consists of replacing 263 HPS fixtures (200 W and 250 W) with LED fixtures (60 LED and 80 LED). Funding for this project came from the EECBG and PG&E (Pacific Gas and Electric Company) turnkey programs. Foster City also later received money from the city to retrofit an additional six streetlights, which are not included in this evaluation.

Annual operating hours for all fixtures were not provided and are assumed to be 12 hours/day on the basis that they are controlled by photocells. Installation verification was performed by randomly sampling 64 percent of 60 LED fixtures which were selected across the city and 100 precent of the 80 LED fixtures. All sampled fixtures were found to have been retrofitted exactly as described in the tracking spreadsheet provided by the city. Ex post energy savings is 100 percent of ex ante estimates.

Life-cycle savings are calculated at 3,645,297 kWh using a 24.4 year EUL for the LED streetlights, provided by PG&E.

Table 69: City Tracking Spreadsheet Retrofit Claims

Pre-Existing Fixtures			Installed Fixtures			
Type	Nominal Wattage	Functional Wattage	Type	Nominal Wattage	Functional Wattage	Fixture Count
HPS	200	234	LED	60	106	239
HPS	200	234	LED	80	139	16
HPS	250	293	LED	80	139	8

Source: DNV KEMA analysis

Table 70: Verification Revised Fixture Table

Pre-Existing Fixtures			Installed Fixtures				
Type	Nominal Wattage	Functional Wattage	Type	Nominal Wattage	Functional Wattage	Fixture Count	Energy Savings
HPS	200	237	LED	60	106	239	137,133
HPS	200	237	LED	80	139	16	6,868
HPS	250	293	LED	80	139	8	5,396
Total							149,397

Source: DNV KEMA analysis

Figure 25: Verification Sample Area Map

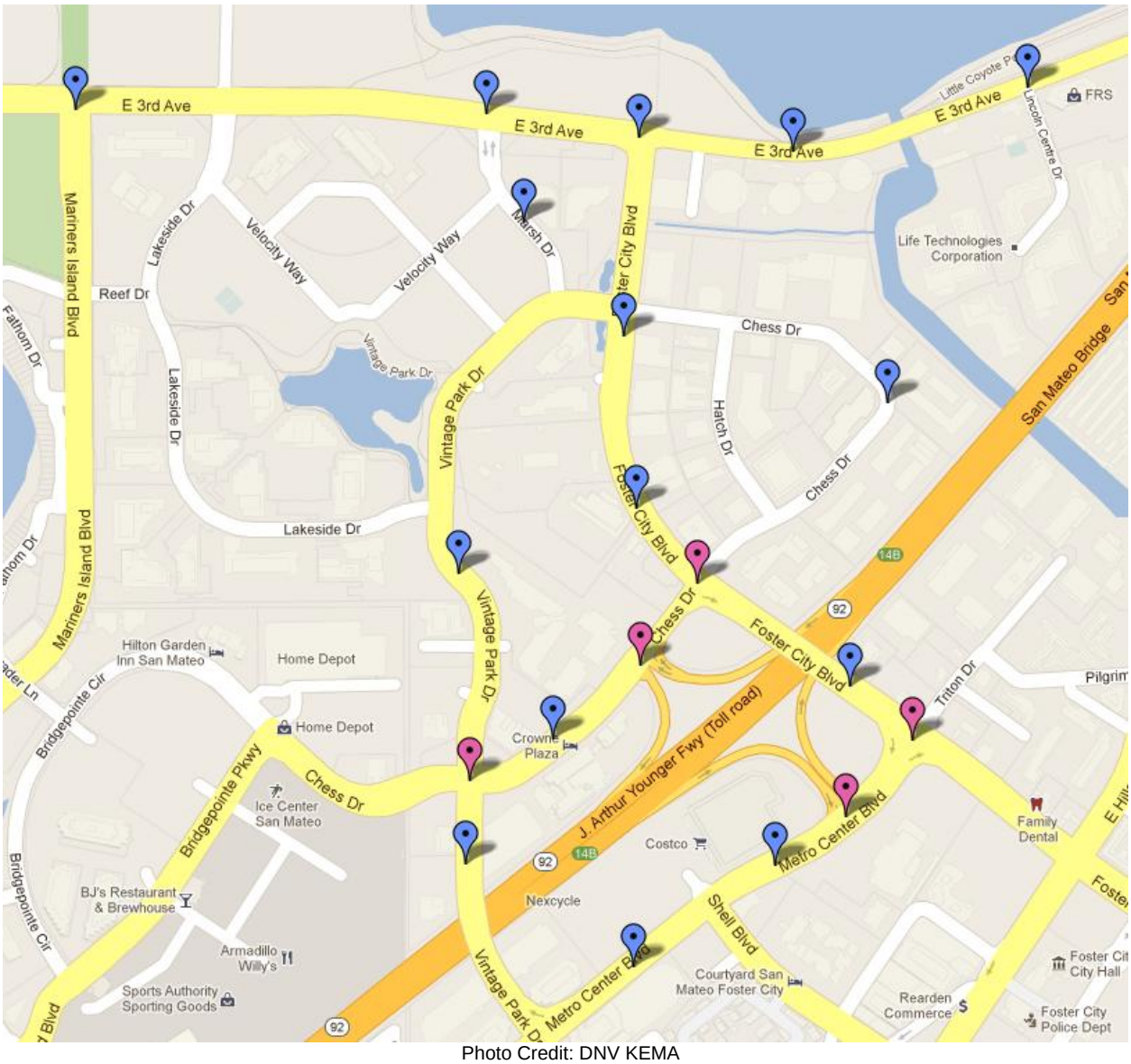


Photo Credit: DNV KEMA

On-site Images

Figure 26: Old HPS Lamps

Photo Credit: DNV KEMA

Figure 27: New 60W LED Lamps

Photo Credit: DNV KEMA

Figure 28: New 80W Lamps

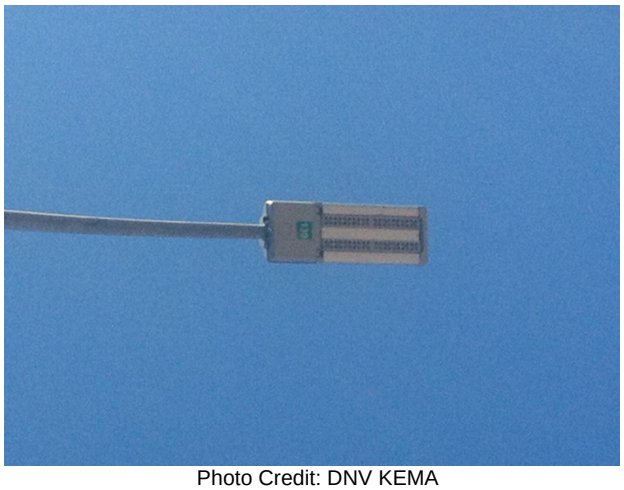


Photo Credit: DNV KEMA

ON-SITE EVALUATION REPORT
EECBG

Yolo, County of (CBG-09-035)

Site Summary

This project involved installing a building management system at the Yolo County Courthouse. This system controls 34 water source heat pumps, eight HVAC package units, and a cooling tower fan and pump. The controls are intended to shut down the HVAC during weekend and evening hours. This project also includes replacing exterior HPS lighting fixtures with LED wall packs and retrofitting parking lot fixtures with LED lamps at 600 A Street in Davis.

Table 71 summarizes the ex ante and ex post savings estimates for this project.

Table 72: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 - Installation of BMS	101,007	NA	2,636	86,496	NA	2,432	86%	92%
EEM2 - Convert existing HPS to LED Lamps	6,000	NA	NA	8,741	NA	NA	146%	NA
Total	107,007	NA	2,636	95,237	NA	2,432	89%	92%

Source: DNV KEMA analysis

EEM1 ex ante savings are based on a utility billing analysis, with simple assumptions for percent savings expected to be achieved by installing the new control system. The ex post analysis is based on nine months of postretrofit billing data and extrapolated to a full year in order to estimate annual energy savings. Although the postretrofit data is limited, the analysis indicates savings are being achieved, albeit slightly less than predicted.

For the lighting retrofit, the higher realization rate is due a greater number of retrofitted fixtures than what is reported in the ex ante analysis.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures

- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For the lighting and HVAC retrocommissioning measures, the baselines are identical. DEER provides a EUL of 14 years for controls. For the street light retrofit, industry standard EUL is 15 years.

Table 73: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline	1,342,059	N/A	34,048

Source: DNV KEMA analysis

Project Description

This project involved installing a building management system at the Yolo County Courthouse. This system controls 34 water source heat pumps, eight HVAC package units, and a cooling tower fan and pump. The controls are intended to shut down the HVAC during weekend and evening hours. This project also includes replacing exterior HPS lighting fixtures with LED wallpacks and retrofitting parking lot light fixtures with LED lamps at 600 A Street in Davis.

Project Evaluation

The evaluation team visited the facility on May 14, 2012, to verify the installation and operation of both lighting and HVAC measures.

Measure 1 – Installation of BMS

EEM1 consisted of installing a building management system to control 34 water source heat pumps, eight packaged air-conditioning units, a cooling tower, a boiler, and associated pumps. The system was previously operated continuously.

ERS collected equipment information for the heat pump and HVAC units. Nameplate data was taken from pump and cooling tower motors. Site contacts were interviewed to verify sequence of operation and scheduled operating hours.

ERS conducted weather bin analysis to validate the ex ante baseline energy use for the HVAC system. ERS calibrated the bin analysis to the utility bill analysis to assess baseline average weekly operating hours. The analysis indicates the HVAC system was operating an average of 60 hours per week. To estimate energy savings, ERS used a utility bill comparison, adjusted for cooling and heating degree days. Only nine months of postretrofit billing data was available for the analysis.

Measure 2 – Retrofit Outdoor Light Fixtures

EEM2 consisted of the installation of LED fixtures replacing existing HPS wallpack fixtures and the retrofit of and parking lot pole light fixtures. Figure 29 shows a retrofitted pole light fixture.

On-site evaluation activities confirmed the quantity, type, and location of the new fixtures and lamps. Site staff confirmed scheduled operating hours for the lamps as reported in the ex ante feasibility study.

Figure 29: LED Pole Light Fixture

Photo Credit: DNV KEMA

Savings were calculated using the following algorithm:

$$\textit{Annual savings (kWh)} = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Pre-retrofit annual hours of operation for usage group, per verified operating hours (4,015 and 1,095 hours)
PostRunHrs	= Postretrofit annual hours of operation for usage group (assumed to be the same)

Savings Results

For the lighting measures, the ex post savings calculations resulted in 8,741 kWh in annual savings.

Discussion

Measure 1– Installation of BMS

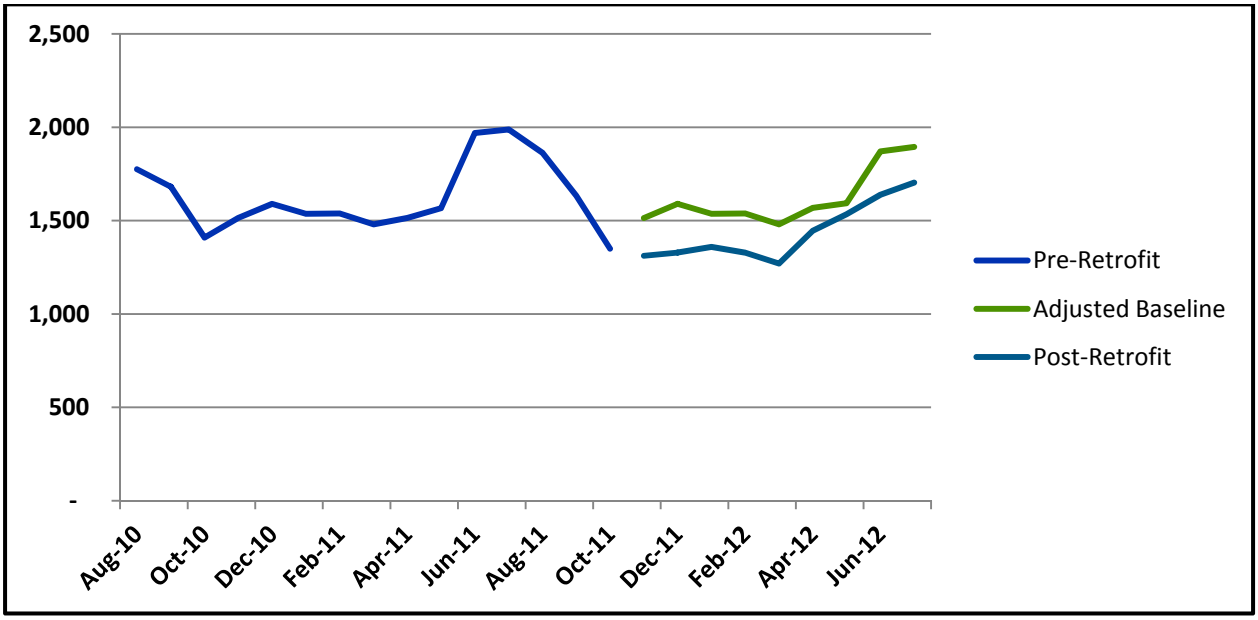
A new building management control system was installed to improve the operational efficiency of the existing HVAC systems, which consisted of packaged units, water source heat pumps, a cooling tower fan, a system loop boiler, and condenser water recirculating pumps. Energy savings are projected to be achieved by shutting off the HVAC equipment during weekend and weeknight hours. The existing system was manually controlled and condenser water equipment (cooling tower fan, pumps, and boiler) were reported to be operating continuously.

Ex ante savings were determined through utility bill analysis. The HVAC was assumed to use 50 percent of the annual energy use (which is somewhat high compared to similar buildings, typically found to be closer to 40 percent). The analysis assumes 33 percent of the annual energy use could be saved by reducing operational run time.

The evaluation team estimated the baseline operating hours per week by calibrating a weather bin analysis using the HVAC equipment data collected on-site and adjusting operational schedules until the estimated energy use match the utility bill estimates. This analysis indicates the ex ante estimated energy use is a reasonable estimate.

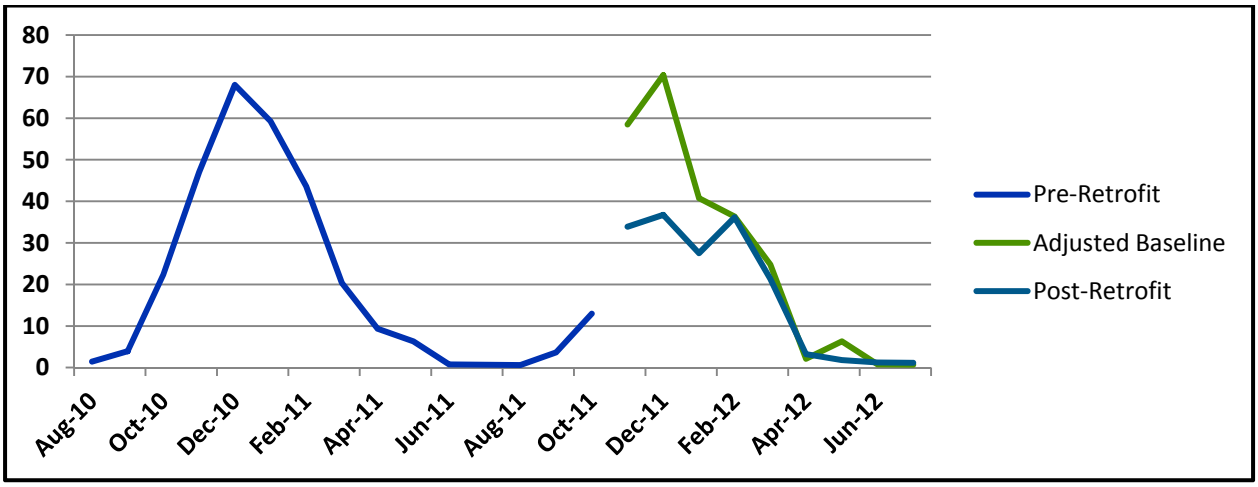
To estimate energy savings, a utility bill analysis was developed. For electric energy savings, an adjusted baseline was calculated by determining the correlation between cooling degree days and kWh/day from pre-retrofit billing data. The resulting regression formula was used to estimate baseline energy use based on cooling degree days during the postretrofit period. Only months with cooling degree days greater than 10 were adjusted. The estimated energy savings is the difference between the adjusted baseline energy use and the post project energy use. Since only nine months of utility billing data was available, and three of the missing months are considered cooling months (August through October), the average energy savings for the missing months was assumed to be equal to the savings achieved in the May-July months. A similar analysis approach was used for estimating natural gas savings, except that no extrapolation was necessary since the postretrofit billing data included all of the heating months.

Figure 30: kWh per Day



Source: DNV KEMA analysis

Figure 31: Therms per Day



Source: DNV KEMA analysis

Measure 2 – Retrofit Outdoor Light Fixtures

All lighting fixture wallpacks and retrofitted pole lights were inspected and verified. Site staff confirmed the scheduled operating hours reported in the project feasibility study and confirmed existing fixture wattages. Lights controlled by the time clock operate 3 hours per day, while the other lights are controlled by photocells and operate 11 hours per day. LED wattages were confirmed from project documentation.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1), as Baseline 1 and 2 are the same for these measures. The baseline considers the existing conditions found prior to the EEM implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 74 provides life-cycle savings for the measures on a year-by-year basis through the EUL of the longest-lived measure.

Table 74: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	95,237	N/A	2,432
2	2013	95,237	N/A	2,432
3	2014	95,237	N/A	2,432
4	2015	95,237	N/A	2,432
5	2016	95,237	N/A	2,432
6	2017	95,237	N/A	2,432
7	2018	95,237	N/A	2,432
8	2019	95,237	N/A	2,432
9	2020	95,237	N/A	2,432
10	2021	95,237	N/A	2,432
11	2022	95,237	N/A	2,432
12	2023	95,237	N/A	2,432
13	2024	95,237	N/A	2,432
14	2025	95,237	N/A	2,432
15	2026	8,741	NA	0
Total		1,342,059		34,048

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Dixon, City of (CBG-09-037)

Site Summary

This streetlight project consisted of replacing 224 HPS fixtures (70 W to 200 W) with 224 LED fixtures (20 W to 60W). Installation verification was performed by randomly sampling 10 fixtures from each region in the city's installation tracking spreadsheet. If the respective region contained less than 10 fixtures, then all of the regional fixtures were verified. A total of 115 fixtures were included in the verification sample. Of the 115 fixtures, all fixtures were found to be retrofitted. No modifications of the city's tracking quantities or fixture wattages were made based on the verification sample.

Table 75: Savings and Realization Rate

Ex Ante Savings	Ex Post Savings	Realization Rate
54,019 kWh	54,019 kWh	100%

Source: DNV KEMA analysis

Table 76: City Tracking Spreadsheet Retrofit Claims

Pre-Existing Fixtures			Installed Fixtures			
Type	Nominal Wattage	Functional Wattage	Type	Nominal Wattage	Functional Wattage	Fixture Count
HPS	70	85	LED	20	37	145
HPS	70	85	LED	30	54	2
HPS	100	120	LED	20	37	2
HPS	100	120	LED	30	54	72
HPS	200	237	LED	60	106	3

Source: DNV KEMA analysis

Table 77: Verification Sample Findings

Pre-Existing Fixtures		Installed Fixtures				
Type	Nominal Wattage	Type	Nominal Wattage	Verified Fixture Count	% of Verification Sample Properly Installed	Average Functional Wattage of Fixtures with Discrepancies
HPS	70	LED	20	79	100%	-

Pre-Existing Fixtures		Installed Fixtures				
Type	Nominal Wattage	Type	Nominal Wattage	Verified Fixture Count	% of Verification Sample Properly Installed	Average Functional Wattage of Fixtures with Discrepancies
HPS	70	LED	30	0	100%	-
HPS	100	LED	20	0	100%	-
HPS	100	LED	30	36	100%	-
HPS	200	LED	60	0	100%	-
Total					100%	

Source: DNV KEMA analysis

Table 78: Verification Revised Fixture Table

Pre-Existing Fixtures			Installed Fixtures					
Type	Nominal Wattage	Functional Wattage	Type	Nominal Wattage	Revised Functional Wattage Based on Verification	Fixture Count	Verified Demand Reduction (kW)	Verified Energy Savings (kWh)
HPS	70	85	LED	20	37	145	6.96	30,485
HPS	70	85	LED	30	54	2	0.06	272
HPS	100	120	LED	20	37	2	0.17	727
HPS	100	120	LED	30	54	72	4.75	20,814
HPS	200	237	LED	60	106	3	0.39	1,721
Total							12.33	54,019

Source: DNV KEMA analysis

Figure 32: Verification Sample Area Map

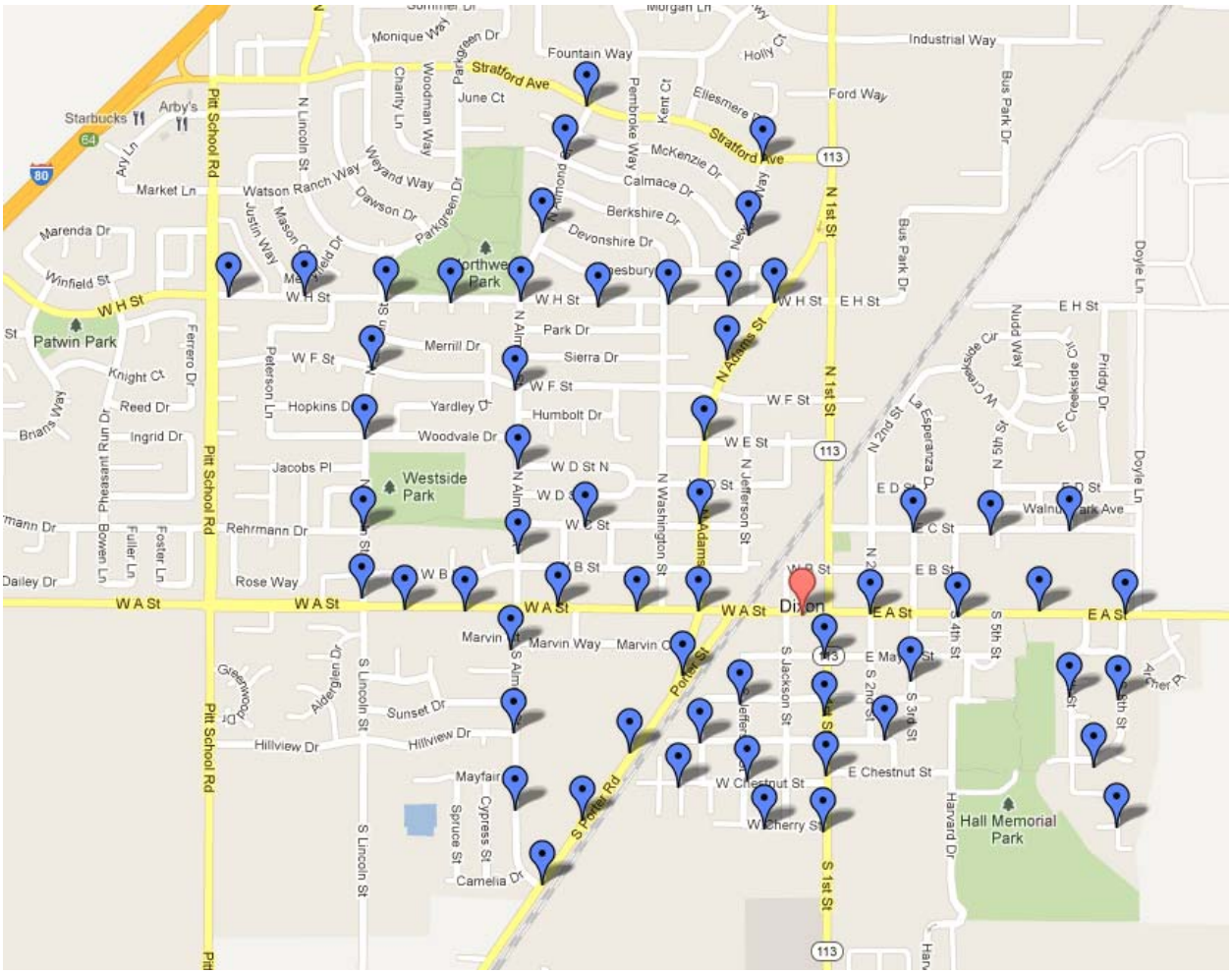


Photo Credit: DNV KEMA

Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EULof the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable. According to the decision maker survey completed with the site contact , the pre-existing streetlighting was installed 25-30 years ago, which was used well beyond its EUL of 15 years.

The tables below provide life-cycle savings for the project relative to Baseline 1 on a year-by-year basis through the EUL of the longest lived measure. Under this baseline, energy savings were presumed to occur relative to the pre-existing equipment for the duration of each measure's life. For this project, the life-cycle savings estimates relative to Baseline 2 (dual baseline) are the same as the life-cycle savings relative to Baseline 1.

Table 79: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therm/yr)
1	2011	54,019	12.3	0
2	2012	54,019	12.3	0
3	2013	54,019	12.3	0
4	2014	54,019	12.3	0
5	2015	54,019	12.3	0
6	2016	54,019	12.3	0
7	2017	54,019	12.3	0
8	2018	54,019	12.3	0
9	2019	54,019	12.3	0
10	2020	54,019	12.3	0
11	2021	54,019	12.3	0
12	2022	54,019	12.3	0
13	2023	54,019	12.3	0
14	2024	54,019	12.3	0
15	2025	54,019	12.3	0
16	2026	0	0	0
	Total	810,285 kWh	185 kW-years	0 therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Walnut, City of (CBG-09-038)

Site Summary

The City of Walnut applied for EECBG funds for three EEMs (EEMs): replacement of four aging rooftop packaged HVAC systems serving the maintenance facility; installation of an HVAC automation control system at all city facilities; and installation of retrofits of interior lighting fixtures at the Walnut City Hall, maintenance facility, Gymnasium/Teen Center, and Senior Center facilities.

DNV KEMA performed site visits at all four facilities that received EECBG funded energy efficiency retrofits. During the site visits, DNV KEMA verified the quantity, manufacturers, and model numbers of the all the installed HVAC equipment and a sample of the lighting equipment. DNV KEMA also gathered HVAC operational schedules and set point temperatures for all the retrofitted systems.

Spreadsheet analysis was used to estimate energy savings for all measures using a combination of site findings and literature reviews. The analysis yielded an overall annual electric energy savings of 52.2 percent when compared to ex ante estimates. The energy and power savings by measure are provided in Table 80.

Table 80: Energy Savings Summary by Measure Category

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Maximum Demand Reduction (kW)[24]	Gas Energy (Therms)	Electric Energy (kWh)	Maximum Demand Reduction (kW)	Gas Energy (Therms)	Electric	Gas
EEM1- Package RTUs	6,589	8.45	-	6,212	7.55	-	94.3%	N/A
EEM2- Building Automation Control	185,038[25]	0.00	-	58,709	0.00	-	31.7%	N/A

24 Maximum demand reduction values for this project were not recorded in the project tracking database provided to KEMA. The ex ante values shown in this table were sourced from the ex ante savings calculation documents provided to KEMA by the project site contact.

25 This value is likely overstated slightly. The Feasibility Study shows that this value reflects two measures, when only one was installed. The Feasibility Study value for this measure alone is 178,449.

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Maximum Demand Reduction (kW)[24]	Gas Energy (Therms)	Electric Energy (kWh)	Maximum Demand Reduction (kW)	Gas Energy (Therms)	Electric	Gas
EEM3- Interior Lighting	121,013	21.8	-	98,420	27.1	-	81.3%	N/A
Total	312,640	30.3	-	163,341	34.6	-	52.2%	N/A

Source: DNV KEMA analysis

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses *minimally code-compliant* conditions or *standard practice* as the baseline once the RUL of the pre-existing equipment is exceeded.

The overall results from Table 1 yield a life-cycle energy savings of 2,450,128 kWh, life-cycle demand savings of 519.4 kW-years when considering Baseline 1 conditions. Using a dual baseline defined as Baseline 2, the life-cycle savings total 2,377,174 kWh and 433.9 kW-years, as shown in Table 81.

Table 81: Ex Post Life-cycle Savings Totals

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1	2,450,115	519.4	-
Baseline 2	2,377,162	433.9	-

Source: DNV KEMA analysis

Project Description

Measure 1: RTU HVAC Systems

This measure involved the replacement of four RTUs at the city's Maintenance facility. These existing and replacement equipment is listed below:

- Three 4-ton packaged RTUs
  - Existing units
    - Manufacturer: Carrier
    - Model Number: 48JD005620
    - 4-ton cooling capacity, 8.37 SEER
    - 58.46 kBTU/hr heating capacity, 75.7 percent AFUE
  - Replacement units

        - Manufacturer: Carrier
        - Model Number: 48HCLA05
        - 4-ton cooling capacity, 15.6 SEER
        - 50 kBTU/hr heating capacity, 81 percent AFUE
- One 3-ton packaged RTU
    - Existing units
        - Manufacturer: Day & Night
        - Model Number: 1PGH036
        - 3-ton cooling capacity, 13 SEER
        - 59 kBTU/hr heating capacity, 82.8 percent AFUE
    - Replacement units
        - Manufacturer: Carrier
        - Model Number: 48HCLA05
        - 4-ton cooling capacity, 15.6 SEER
        - 47 kBTU/hr heating capacity, 81 percent AFUE

Measure 2: HVAC Automation Control System

This measure enables remote monitoring and scheduling capability for all HVAC equipment at the city facilities. This measure allows for easy programming of reoccurring or single events, and for holiday shut downs of the equipment. Additionally, standby temperature set points can be programmed for deployment during a load shed event. The HVAC units operated by the HVAC Automation Control System are shown below in Table 82.

Table 82: RTUs Operated by HVAC Automation Control System

Location	Cooling Capacity (tons)	Quantity
City Hall	6	1
City Hall	5	3
City Hall	4	1
City Hall	3	6
City Hall	2.5	1
City Hall	2	2
City Hall	1.5	3
Gym/Teen Center	25	2
Gym/Teen Center	12.5	2
Gym/Teen Center	10	1
Gym/Teen Center	7.5	1
Gym/Teen Center	6	1
Maintenance Facility	4	4

Location	Cooling Capacity (tons)	Quantity
Senior Center	20	3
Senior Center	6	1
Senior Center	5	3
Senior Center	3	1

Source: DNV KEMA analysis

Measure 3: Interior Lighting

This measure involved retrofits of existing interior lighting components to higher efficiency fixtures and bulbs, as well as installation of daylight harvesting lighting controls and vending machine controls. The planned lighting and control retrofits, organized by facility, are listed below:

- Gymnasium/ Teen Center
  - x3 2′ 2-lamp retrofits from T8 to T8 (new gen) lighting
  - x45 4′ 2-lamp retrofits from T8 to T8 (new gen) lighting
  - x19 4′ 2-lamp retrofits from T12 to T8 (new gen) lighting
  - x86 4′ 3-lamp retrofits from T8 to T8 (new gen) lighting
  - x2 4′ 1-Lamp retrofits from T12 to T8 (new gen) lighting
  - x2 6′ 2-Lamp retrofits from T12 to T8 (new gen) lighting
  - x4 exit sign retrofits from incandescent to LED lighting
  - x39 4-lamp High Bay T5 retrofits from 400W MH lighting
  - x22 1-lamp High Bay T5 retrofits from 100W MH lighting
  - x29 Daylight harvesting controls
  - x1 Vending machine controls
- Maintenance facility
  - x 20 4′ 2-lamp retrofits from T12 to T8 (new gen) lighting
  - x46 4′ 3-lamp retrofits from T12 to T8 (new gen) lighting
  - x1 4′ 8-lamp retrofits from T12 to T8 (new gen) lighting
  - x8 4′ 4-lamp T8 (new gen) lighting from 8′ 2-lamp T12 lighting
  - x6 Daylight harvesting controls
  - x2 Vending machine controls
- Senior Center
  - x155 2′ 4-lamp retrofits from T8 to T8 (new gen) lighting
  - x4 4′ 3-lamp retrofits from T8 to T8 (new gen) lighting
  - x23 Daylight harvesting controls

Ex Ante Savings

Measure 1: RTU HVAC Systems

Annual energy savings was claimed for this measure while demand reduction and therm savings were not claimed. The ex ante demand reduction value reported in the Site Summary

section was determined as part of the annual energy savings calculation but no demand reduction was claimed. This ex ante method only considered cooling loads and did not claim or calculate ex ante therm savings, yet a change in therm consumption would be expected as a result of this measure.

The ex ante annual energy savings calculations for the package rooftop HVAC units were performed using the Energy Commission HVAC calculator. From the documentation provided by the site contact, this calculator determined annual energy consumption for the existing and postretrofit equipment. The annual energy consumption equation considered total unit power (kW), number of units, annual operating hours, and a percent (cooling) load factor. The equation for annual energy consumption (kWh) is shown below:

$$Annual\ kWh_{existing\ or\ replacement} = \frac{kW}{unit} \cdot \#\ of\ units \cdot annual\ operating\ hours \cdot \%\ load$$

With the calculation of annual hours using the following equation:

$$Annual\ operating\ hours = \frac{hours}{day} \cdot \frac{days}{week} \cdot \frac{weeks}{year}$$

Annual energy savings for the RTUs were then calculated as the difference between the existing to the retrofit equipment annual energy consumption calculations, as shown in the following equation:

$$Annual\ kWh\ savings = Annual\ kWh_{existing} - Annual\ kWh_{replacement}$$

Maximum demand reduction was calculated as the difference in maximum electrical power consumption (kW) between the existing and replacement units, multiplied by the number of units. The equation for maximum demand reduction (kW) is shown below:

$$kW\ savings = \left[\left(\frac{kW}{unit}\right)_{existing} - \left(\frac{kW}{unit}\right)_{replacement}\right] \times \#\ of\ units$$

The ex ante savings analysis input parameters and results are presented below in Table 83.

Table 83: Measure 1 Ex Ante Savings Analysis Parameters and Results

Equipment	# of units	kW /unit	Daily Hours	Days /week	Weeks /year	Annual Hours	% Load Factor	Energy Consumption (kWh)	Demand Reduction (kW)
Existing	4	5.28	15	5	52	3,900	20%	16,474	21.12
Retrofit	4	3.17	15	5	52	3,900	20%	9,885	12.67
Savings		2.11						6,589	8.45

Source: DNV KEMA analysis

Measure 2: HVAC Automation Control System

The 185,038 annual kWh savings recorded for this measure in the project tracking database is likely incorrect. This value includes annual kWh savings for both Measure 1 and 2, as presented in Appendix C of the "FEASIBILITY STUDY 2: HVAC Upgrade and Global Building

Automation Control System Installation" that was provided to DNV KEMA by the site contact. The correct ex ante calculated annual energy savings is 178,449 kWh. The Site Summary measure and project realization rates are calculated against the project tracking database values while the following ex ante savings calculations and values reflect what was found in the feasibility report.

The ex ante savings calculations for the HVAC automation control system were performed by applying engineering equations to the existing building schedule and assumed postretrofit schedules for all units at a particular facility. This ex ante method only considered cooling loads, and therefore did not include any possible therm savings. The energy savings for each facility was the difference in energy consumption between the existing schedule and the postretrofit schedule for all the units.

The annual operating hours for all units at all facilities were calculated using the following equation:

$$Annual\ operating\ hours = \frac{\#\ hours}{day} \cdot \frac{\#\ days}{week} \cdot \frac{\#\ weeks}{year} \cdot Cycle\%$$

The ex ante savings calculations assumed the following schedule parameters for all facilities:

- Hours of operation per day
  - Existing: 14
  - Postretrofit: 9
- Days of operation per week: 5
- Week of operation per year: 52
- Cycle percent: 62.5 percent

The cycle percent value is the estimated annual cooling load percentage calculated from the average of monthly cooling load percentages. The monthly values used for the calculation are shown below in Table 84.

Table 84: Ex Ante Assumed Monthly Cooling Load Values

Month	Cooling Load %
January	30%
February	50%
March	50%
April	60%
May	60%
June	70%
July	90%
August	100%
September	90%

Month	Cooling Load %
October	70%
November	50%
December	30%
Annual Average	62.5%

Source: DNV KEMA analysis

The annual operating hours for each unit under the existing schedule totaled 2,275 hours per year, while each unit operating under the postretrofit schedule totaled 1,462.5 hour per year.

The ex ante engineering equation used the annual operating hours parameter with an assumed kilowatt per ton efficiency value for each size of rooftop, the cooling capacity of the units, and the number of units of that size at each facility to calculate total annual energy consumption at each of the four retrofitted facilities. The equation to calculate annual energy consumption for a group of RTUs of a specific cooling capacity is represented below:

$$Annual\ kWh = \#\ units \cdot \frac{cooling\ tons}{unit} \cdot \frac{kW}{ton} \cdot annual\ operating\ hours$$

Kilowatt per ton values ranged from 0.88 to 0.99 kW per ton and had a weighted average value of 0.93 kW per ton. From the ex ante calculation documentation it is not entirely clear how the kilowatt per ton efficiency value was determined for each of the cooling capacity entries.

Annual energy savings for each group of RTUs was then calculated as the difference in annual energy consumption for the existing and retrofit cases, as shown in the following equitation:

$$Annual\ kWh\ savings_{group} = Annual\ kWh_{existing} - Annual\ kWh_{retrofit}$$

Total kWh electrical energy savings was then calculated from the sum of the kWh savings from all RTU groups. The results of the ex ante HVAC automation control system savings analysis is presented below in Table 85.

Table 85: Measure 2 Ex Ante Calculated Savings

Location	Cooling Capacity (Tons)	# of Units	kW /ton	Existing Annual Hours	Existing Annual Energy (kWh)	Retrofit Annual Hours	Retrofit Annual Energy (kWh)	kWh Savings	Facility kWh Savings
City Hall	1.5	3	0.99	2,275	10,169	1,463	6,537	3,632	41,454
	2	2	0.94	2,275	8,508	1,463	5,470	3,038	
	2.5	1	0.94	2,275	5,369	1,463	3,451	1,918	
	3	6	0.95	2,275	39,039	1,463	25,097	13,943	
	4	1	0.98	2,275	8,895	1,463	5,718	3,177	
	5	3	0.93	2,275	31,804	1,463	20,446	11,359	
	6	1	0.90	2,275	12,285	1,463	7,898	4,387	
Gym/ Teen	6	1	0.90	2,275	12,285	1,463	7,898	4,387	63,489

Location	Cooling Capacity (Tons)	# of Units	kW /ton	Existing Annual Hours	Existing Annual Energy (kWh)	Retrofit Annual Hours	Retrofit Annual Energy (kWh)	kWh Savings	Facility kWh Savings
Center	7.5	1	0.89	2,275	15,265	1,463	9,813	5,452	
	10	1	0.93	2,275	21,226	1,463	13,645	7,581	
	12.5	2	0.87	2,275	49,231	1,463	31,648	17,583	
	20	2	0.88	2,275	79,762	1,463	51,275	28,486	
Maintenance	4	4	0.98	2,275	35,581	1,463	22,874	12,707	12,707
Senior Center	3	1	0.95	2,275	6,507	1,463	4,183	2,324	60,799
	5	3	0.93	2,275	31,805	1,463	20,445	11,359	
	6	1	0.90	2,275	12,285	1,463	7,898	4,387	
	20	3	0.88	2,275	119,642	1,463	76,913	42,729	
Total					499,658		321,209	178,449	178,449

Source: DNV KEMA analysis

Measure 3: Interior Lighting

The ex ante savings calculations for the lighting and control retrofits were performed using spreadsheet based engineering calculations.

The ex ante kWh electrical energy savings analysis method for retrofitted fixtures calculates the existing and postretrofit annual kWh energy consumption of each unique combination of fixture location and type. The difference in annual energy consumption from the existing case to the postretrofit case is the annual energy savings. The input parameters to calculate annual energy consumption are: fixture input power, fixture quantity, and annual operating hours. The annual kWh electrical energy consumption equation for each lighting group is shown below:

$$Annual\ kWh_{lighting\ group} = \frac{input\ power\ (W) \cdot \#\ of\ Fixtures \cdot Annual\ operating\ hours}{1000\,\frac{W}{kW}}$$

Annual kWh energy savings is then calculated using the equation below:

$$Annual\ kWh\ savings_{lighting\ group=}\ Annual\ kWh_{existing\ group} - \ Annual\ kWh_{retrofit\ group}$$

Total kWh electrical energy savings was then calculated from the sum of the kWh savings from all lighting groups.

According to the calculation spreadsheet provided by the site contact, the ex ante kW demand savings for lighting retrofits was calculated as the difference in total power for each grouping of fixture types and location. The equation for the difference in total power for each lighting group is show below:

$$kW\ savings_{lighting\ group} = \frac{\left[input\ power\ (W)_{existing} - input\ power\ (W)_{retrofit}\right]}{1000\,\frac{W}{kW}} \cdot \#\ of\ Fixtures$$

The total demand savings were calculated from the sum of the kW savings from all lighting groups.

It was not clear how the ex ante annual energy savings for the daylight harvesting was calculated. DNV KEMA attempted to back out the savings calculation method from the paper copies of the San Gabriel Valley Energy Wise Partnership's *Energy Efficiency Assessment Report* containing the ex ante saving calculation for this measure, but a consistent reduction in operation hours could not be determined from the available documentation. No demand savings was claimed for this control type.

The ex ante annual energy savings from the installation of the vending machine controls was listed as 1,600 kWh for each installed control. The *Energy Efficiency Assessment Report* does not identify the basis of this savings value. No demand savings was claimed for this control type.

On the next page, Table 86 shows the input parameters and savings results for all fixture and control types.

Table 86: Measure 3 Ex Ante Calculated Savings

Site ID / Location	Existing Fixture Descrip-Tion	Existing Fixture Watt	Existing Fixture Count	Annual Oper. hours	Annual kWh Consump.	Retrofit Fixture Descrip-tion	Retrofit Fixture Watt	Retrofit Fixture Count	Annual Oper. Hours	Annual kWh Consump.	Annual kWh Savings	Demand Savings, kW
Gym/ Teen Center	2' 2-Lamp U T-8	60	3	4,160	749	2' 2-Lamp U T-8	34	3	4,160	424	324	0.08
Gym/ Teen Center	4' 2-Lamp T-8	60	45	4,160	11,232	4' 2-Lamp T-8	37	45	4,160	6,926	4,306	1.04
Gym/ Teen Center	4' 2-Lamp T-12	80	19	4,160	6,323	4' 2-Lamp T-8	37	19	4,160	2,924	3,399	0.82
Gym/ Teen Center	4' 3-Lamp T-8	89	86	4,160	31,841	4' 3-Lamp T-8	72	86	4,160	25,759	6,082	1.46
Gym/ Teen Center	4' 1-Lamp T-12	40	2	4,160	333	4' 1-Lamp T-8	19	2	4,160	158	175	0.04
Gym/ Teen Center	6' 2-Lamp T-12	120	2	4,160	998	6' 2-Lamp T-12	76	2	4,160	632	366	0.09
Gym/ Teen Center	Incandescent Exit Signs	24	4	8,760	841	LED Exit Signs	5	4	8,760	175	666	0.08
Gym/ Teen Center	MH	128	22	4,160	11,715	1-Lamp HB T-5	63	22	4,160	5,766	5,949	1.43
Gym/ Teen Center	MH	458	39	4,160	74,306	4-Lamp HB T-5	250	39	4,160	40,560	33,746	8.11
Gym/ Teen Center	None	0	0	0	0	Daylight Controls	0	29	0	-8,535	8,535	0.00
Gym/ Teen Center	None	0	0	0	0	Vending Controls	0	1	0	-1,600	1,600	0.00

Site ID / Location	Existing Fixture Descrip-Tion	Existing Fixture Watt	Existing Fixture Count	Annual Oper. hours	Annual kWh Consump.	Retrofit Fixture Descrip-tion	Retrofit Fixture Watt	Retrofit Fixture Count	Annual Oper. Hours	Annual kWh Consump.	Annual kWh Savings	Demand Savings, kW
Mainten-ance	4' 2-Lamp T-12	80	20	3,019	4,830	4' 2-Lamp T-8	37	20	3,019	2,234	2,596	0.86
Mainten-ance	4' 3-Lamp T-12	126	46	3,019	17,498	4' 3-Lamp T-8	72	46	3,019	9,999	7,499	2.48
Mainten-ance	8' 2-Lamp T-12	136	8	3,019	3,285	4' 4-Lamp T-8	96	8	3,019	2,319	966	0.32
Mainten-ance	4' 8-Lamp T-12	320	1	3,019	966	4' 8-Lamp T-8	192	1	3,019	580	386	0.13
Mainten-ance	None	0	0	0	0	Daylight Controls	0	6	0	-2,750	2,750	0.00
Mainten-ance	None	0	0	0	0	Vending Controls	0	2	0	-3,200	3,200	0.00
Senior Center	2' 4-Lamp T-8	68	155	4,160	43,846	2' 4-Lamp T-8	37	155	4,160	23,858	19,989	4.81
Senior Center	4' 3-Lamp T-8	89	4	4,160	1,481	4' 3-Lamp T-8	72	4	4,160	1,198	283	0.07
Senior Center	None	0	0	0	0	Daylight Controls	0	23	0	-18,191	18,191	0.00
	Totals		456		210,244	Totals		517		89,236	121,008	21.8

Source: DNV KEMA analysis

Rounding error produced the 5 kWh annual savings difference between the Table 86 value and the claimed savings in Table 80.

Project Evaluation

A DNV KEMA field engineer visited the project sites on May 22nd, 2012 to verify the measure installations and gather data on equipment model numbers, quantities, and control schemes. Table 87 summarizes the results of the installation verification.

Table 87: Verification Summary

Site	Equipment	Quantity Reported	Quantity Verified	Site Notes
Maintenance facility	4-ton Carrier packaged RTUs	4	4	Ex ante claimed Carrier M/N: 48PDLC05, ex post found Carrier M/N: 48CLA05
All city facilities	HVAC automation control system	1	1	Verified system operational at Senior Center, City Hall, Gymnasium/ Teen Center, Maintenance facility
City Hall, Gymnasium	2' 2-Lamp U T8	3	70	
Senior Center	2' 4-Lamp T8	155	155	
City Hall	4' 1-Lamp T8	0	10	
City Hall, Gymnasium, Maintenance Facility	4' 2-Lamp T8	84	268	
Gymnasium, Maintenance Facility, Senior Center	4' 3-Lamp T8	136	136	
Maintenance facility	4' 4-Lamp T8	8	0	No new 4' 4-Lamp T8 fixtures installed
Maintenance facility	4' 8-Lamp T8	1	1	
Gymnasium	6' 2-Lamp T8	2	0	No new 6' 2-Lamp T8 fixtures installed
Gymnasium	4-Lamp High Bay T5	39	39	
Gymnasium	1-Lamp High Bay T5	22	22	
Gymnasium	LED Exit Signs	4	4	

Source: DNV KEMA analysis

Measure 1: RTU HVAC Systems

The ex post Measure 1 savings analysis was based upon a five-degree (˚F), weather bin analysis spreadsheet method utilizing the local TMY3 weather data set, operating schedules and set point temperatures to derive heating and cooling loads. The bin analysis assumed the following: the HVAC equipment is properly sized to meet heating and cooling loads of buildings and the heating and cooling loads are ambient-temperature driven and have a near-linear relationship with ambient temperature.

During the site visit, DNV KEMA verified the installations of the HVAC equipment, acquired model numbers and capacity nameplate information, and gathered operational schedules and set point temperatures from the site contact. Subsequently, DNV KEMA determined heating and cooling efficiency values for the RTUs from manufacturer literature and gathered TMY3 hourly, ambient dry-bulb temperature data from the nearby Burbank-Glendale airport.

As per the set point temperature information provided by the site contact, the building cooling load occurs between the 65-70°F ambient temperature bin and the 105-110°F bin. The bin analysis model considers the hours of operation along with flags set to indicate cooling months. To compare the ex ante calculated year round cooling, all months were flagged as cooling months for the ex post analysis. This method captures what cooling would occur during the cooler winter months, in place of accounting for the heating that is likely also occurring during other times within the winter period. DNV KEMA investigated performing the savings analysis with the heating load modeled from November through May as indicated by the number of heating and cooling degree days in each month for California Climate Zone 9. For this warm climate zone and the specific unit in this measure, focusing the modeling on the cooling load results in more overall savings. The HVAC systems operate weekdays from 6 a.m. to 9 p.m. The cooling set point occupied temperature for all four RTUs is 72°F.

In regards to cooling for Baseline 1, all SEER/ ERR values for existing units were reduced by 10 percent from the value listed in the project description to account for age-related performance degradation. For Baseline 2, all replacement units were calculated against the CEE Tier 1 SEER value of 14.

Electric demand savings for the cooling equipment were calculated at full-load cooling capacity by taking the difference between the energy consumption of the high-efficiency replacement units and that of the existing units (for Baseline 1 conditions) or that of normal-efficiency replacement units (for the Baseline 2 conditions).

The ex post analysis results for Baseline 1 conditions can be seen below in Table 88.

Table 88: Measure 1 Ex Post Savings Calculation Summary

Equipment			Existing Unit			Retrofit Unit			Energy Savings	Demand Reduction
Location	Cooling Capacity (Tons)	# of Units	kW/ton	Unit kWh	kWh	kW/ton	Unit kWh	kWh	kWh Savings	kW Savings
Maintenance	4	3	1.43	4,250	12,751	0.77	2,304	6,912	5,838	7.89
	3(existing), 4 (replacement)	1	0.92	2,217	2,217	0.77	1,843	1,843	374	-0.34
Total		4			14,968			8,755	6,212	7.55

Source: DNV KEMA analysis

This analysis yielded a first-year annual energy savings of 6,212 kWh and first-year electric demand savings of 7.55 kW under Baseline 1 conditions.

Measure 2: HVAC Automation Control System

The ex post Measure 2 savings analysis was based upon a five-degree (˚F), weather bin analysis spreadsheet method utilizing the local TMY3 weather data set and set point temperatures together with pre and postretrofit operating schedules to derive change in cooling loads resulting from the reduced operational hours afforded by this control measure. The weather bin analysis spreadsheet calculated annual energy consumption for both the pre and postretrofit schedules for each unit. Annual energy savings was then calculated by subtracting the annual energy consumption of the postretrofit schedule from the annual energy consumption of the existing schedule.

To compare the ex ante calculated year round cooling only, all months were flagged as cooling months for the ex post analysis. This method captures what cooling would occur during the cooler winter months, in place of accounting for the heating that is likely also occurring during other times within the winter period.

DNV KEMA used the operational hours listed for each facility in the HVAC automation control feasibility study as the existing schedule, while postretrofit schedules were gathered from the HVAC automation control system during the site visit. A table of the existing and postretrofit schedules used in the analysis is included in this report submission.

On the next page, Table 89 displays the annual energy consumption for the existing and postretrofit cases as well as the annual energy saving by type of RTU, by facility, and for the whole measure.

Table 89: Measure 2 Ex Post Savings Calculation Summary

Equipment			Existing Schedule		Postretrofit Schedule		Savings	
Location	Cooling Capacity (Tons)	# of Units	kWh	Facility kWh	kWh	Facility kWh	Equipment Savings	Facility Savings
City Hall	6	1	6,025	48,852	6,344	51,434	-318	-2,583
	5	2	8,588		9,042		-454	
	5	1	4,294		4,521		-227	
	4	1	3,193		3,362		-169	
	3	5	12,773		13,448		-675	
	3	1	2,980		3,138		-158	
	2.5	1	2,058		2,167		-109	
	2	2	4,087		4,303		-216	
	1.5	3	4,854		5,110		-257	
Gym/ Teen Center	25	2	81,125	157,606	57,615	126,651	23,510	30,955
	13	2	40,176		38,438		1,738	

Equipment			Existing Schedule		Postretrofit Schedule		Savings	
Location	Cooling Capacity (Tons)	# of Units	kWh	Facility kWh	kWh	Facility kWh	Equipment Savings	Facility Savings
	10	1	15,340		10,540		4,800	
	8	1	11,505		11,007		498	
	6	1	9,460		9,050		409	
Maintenance	4	3	9,010	12,042	8,165	9,213	846	2,830
	4	1	3,032		1,048		1,984	
Senior Center	20	2	59,079	119,821	49,475	92,314	9,603	27,507
	20	1	29,539		24,167		5,372	
	6	1	7,898		5,313		2,584	
	5	1	6,510		2,776		3,734	
	5	2	13,021		7,316		5,705	
	3	1	3,774		3,265		509	
Total			338,321	338,321	279,611	279,611	58,709	58,709

Source: DNV KEMA analysis

This analysis yielded a first-year annual energy savings of 58,709 kWh under Baseline 1 conditions. No first-year electric demand savings resulted from this measure.

Measure 3: Interior Lighting

The ex post savings calculations for the lighting retrofits were performed using the same spreadsheet calculation approach as the ex ante method described in the prior section of this report.

During the on-site visit, DNV KEMA verified 705 lighting fixture retrofits. DNV KEMA found the following retrofits were not planned ex ante, but were performed under this this measure:

- City Hall
  - x67 2′ 2-lamp retrofits from T8 to T8 (new gen) lighting
  - x10 4′ 1-lamp retrofits from T8 to T8 (new gen) lighting
  - x184 4′ 2-lamp retrofits from T8 to T8 (new gen) lighting

DNV KEMA found the following lighting fixtures and controls were not retrofitted:

- Gymnasium/ Teen Center
  - x29 Daylight harvesting controls
  - x1 Vending machine controls
- Maintenance facility
  - x8 4′ 4-lamp T8 (new gen) lighting from 8′ 2-lamp T12 lighting
  - x6 Daylight harvesting controls
  - x2 Vending machine controls
- Senior Center
  - x23 Daylight harvesting controls

For the ex post savings analysis, DNV KEMA assigned the annual hours of operation based upon the lighting and occupancy schedule information acquired from the site contact. For the City Hall facility, these were less than the ex ante hours claimed. Additionally, the 205 fixtures that are controlled by occupancy sensors were allocated a 30 percent reduction in annual operating hours. The savings input parameters and savings results are shown on the next page in Table 90.

Table 90: Measure 3 Ex Post Calculated Savings

Site ID / Location	Existing Fixture Description	Existing Fixture Watts	Existing Fixture Count	Annual Oper. Hours	Annual kWh Consump.	Retrofit Fixture Description	Retrofit Fixture Watts	Retrofit Fixture Count	Annual Oper. Hours	Annual kWh Consump.	Annual kWh Savings	Demand Savings, kW
City Hall	4' 2-Lamp T-8	60	144	2,600	22,464	4' 2-Lamp T-8	37	144	2,600	13,853	8,611	3.31
City Hall	4' 2-Lamp T-8 on OS	60	40	2,080	4,992	4' 2-Lamp T-8 on OS	37	40	1,820	2,694	2,298	0.92
City Hall	4' 1-Lamp T-8	32	10	2,600	832	4' 1-Lamp T-8	19	10	2,600	494	338	0.13
City Hall	2' 2-Lamp U T-8	60	57	2,600	8,892	2' 2-Lamp U T-8	34	57	2,600	5,039	3,853	1.48
City Hall	2' 2-Lamp U T-8 on OS	60	10	2,080	1,248	2' 2-Lamp U T-8 on OS	34	10	1,820	619	629	0.26
Gym/ Teen Center	2' 2-Lamp U T-8	60	3	4,160	749	2' 2-Lamp U T-8	34	3	4,160	424	324	0.08
Gym/ Teen Center	4' 2-Lamp T-8	60	51	4,160	12,730	4' 2-Lamp T-8	37	51	4,160	7,850	4,880	1.17
Gym/ Teen Center	4' 2-Lamp T-8 on OS	60	13	3,328	2,596	4' 2-Lamp T-8 on OS	37	13	2,912	1,401	1,195	0.30
Gym/ Teen Center	4' 3-Lamp T-8	89	64	4,160	23,695	4' 3-Lamp T-8	72	64	4,160	19,169	4,526	1.09
Gym/ Teen Center	4' 3-Lamp T-8 on OS	89	22	3,328	6,516	4' 3-Lamp T-9 on OS	72	22	2,912	4,613	1,904	0.37
Gym/ Teen Center	Incandescent Exit Signs	24	4	8,760	841	LED Exit Signs	5	4	8,760	175	666	0.08
Gym/ Teen Center	MH	128	22	4,160	11,715	1-Lamp High Bay T-5	63	22	4,160	5,766	5,949	1.43
Gym/ Teen Center	MH	458	39	4,160	74,306	4-Lamp High Bay T-5	250	39	4,160	40,560	33,746	8.11
Maintenance	4' 2-Lamp T-12	80	20	3,019	4,830	4' 2-Lamp T-8	37	20	3,019	2,234	2,596	0.86
Maintenance	4' 3-Lamp T-12	126	36	3,019	13,694	4' 3-Lamp T-8	72	36	3,019	7,825	5,869	1.94

Site ID / Location	Existing Fixture Description	Existing Fixture Watts	Existing Fixture Count	Annual Oper. Hours	Annual kWh Consump.	Retrofit Fixture Description	Retrofit Fixture Watts	Retrofit Fixture Count	Annual Oper. Hours	Annual kWh Consump.	Annual kWh Savings	Demand Savings, kW
Maintenance	4' 3-Lamp T-12 on OS	126	10	2,415	3,043	4' 3-Lamp T-8 on OS	72	10	2,113	1,522	1,522	0.54
Maintenance	4' 8-Lamp T-12	320	1	3,019	966	4' 8-Lamp T-8	192	1	3,019	580	386	0.13
Senior Center	4' 3-Lamp T-8	89	4	4,160	1,481	4' 3-Lamp T-8	72	4	4,160	1,198	283	0.07
Senior Center	2' 4-Lamp T-8	68	45	4,160	12,730	2' 4-Lamp T-8	37	45	4,160	6,926	5,803	1.40
Senior Center	2' 4-Lamp T-8 on OS	68	110	3,328	24,893	2' 4-Lamp T-8 on OS	37	110	2,912	11,851	13,042	3.41
	Totals	2,117	705		233,213	Totals	1,250	705		134,793	98,420	27.08

Source: DNV KEMA analysis

This analysis yielded a first-year annual energy savings of 98,420 kWh and a first-year electric demand savings of 27.08 kW under Baseline 1 conditions.

Savings Results and Discussion

The project saved 163,342 kWh of electric energy in the first year and represents a realization rate of 52.2 percent for electric energy when compared to the ex ante estimated savings. Furthermore, the project reduced summer on-peak demand by 34.6 kW in the first year.

Measure 1: RTU HVAC Systems

Sources of uncertainty regarding these HVAC calculations included the assumed level of degradation of the existing equipment, reliance on billing data to calibrate pre-retrofit modeled energy use, and the assumptions inherent in the bin analysis method regarding equipment sizing and building cooling and heating loads being primarily weather dependent.

DNV KEMA's slightly reduced estimate of EEM1's electrical energy (kWh) savings (94.3 percent realization rate) was due to differences in existing and replacement unit efficiency values, as well as differing cooling capacities and for one existing unit.

The ex ante savings analysis assumed all existing units were 4-ton cooling capacity. Information gathered from the site contact during the on-site visit revealed that there were three 4-ton existing Carrier units and one existing 3-ton Day & Night unit. For the ex post analysis, this unit was modeled with the existing 3-ton, 0.92 kW/ton unit being replaced by a new 4-ton, 0.77 kW/ton unit. The ex post 0.92 kW/ton efficiency value for this unit is lower than the ex ante assumed 1.32 kW/ton of the 4-ton units, and so the efficiency gain from the replacement unit is reduced. For the ex post modeling, DNV KEMA assumed the existing unit operated at a similar load factor as the other 4-ton units (~20 percent), but being of smaller cooling capacity delivered less cooling. To model the replacement 4-ton unit delivering the same amount of cooling as the existing 3-ton unit, the full load hours for the replacement unit were significantly reduced. Savings is therefore reduced for this unit because the reduced cooling load produces fewer kWh saved from the increase in unit efficiency.

For the other three RTUs, the ex ante savings analysis assumed the existing and replacement units had kW/ton efficiency values of 1.32 and 0.79, respectively. The ex post analysis used values of 1.43 kW/ton for existing units and 0.77 kW/ton for the replacement units. This greater difference in efficiency values for the ex post analysis produced more savings than the ex ante analysis. This increase in unit savings partially offset the lower savings from the other RTU.

DNV KEMA's slightly lower ex post savings estimate for maximum demand reduction (7.55 kW versus 8.44 kW) was primarily due to replacement of one existing 3-ton unit which had a maximum demand of 2.77 kW with a larger 4-ton unit which has a maximum demand of 3.11 kW. This change actually increased demand by 0.34 kW for this unit. The remaining three units reduced maximum demand by 2.63 kW per unit, more than the ex ante estimate of 2.11kW demand reduction.

Measure 2: HVAC Building Automation Control System

Sources of uncertainty regarding these HVAC calculations included the assumed level of degradation of the existing equipment, reliance on billing data to calibrate pre-retrofit modeled energy use, and the assumptions inherent in the bin analysis method regarding equipment sizing and building cooling and heating loads being primarily weather dependent.

DNV KEMA's lower estimate of electric energy (kWh) savings for EEM2 (31.7 percent realization rate) was primarily due to differences in calculating full load operating hours.

The ex ante savings calculations were based on a reduction of daily operating hours from 14 to 9 hours for all units while keeping the loading factor constant at 62.5 percent. The result is a reduction of 813 annual full load operating hours for each unit.

The ex post analysis considered the change in schedules for each cooling capacity group at each facility based upon the existing schedules documented in the Measure 2 feasibility report and the post Measure 2 retrofit schedule that was gathered on-site. Then, each cooling capacity group at each facility was modeled using the pre and postretrofit schedules.

The ex post method takes into account the effect the schedule change has on the cooling load and it therefore alters the operating hours and average cooling load, whereas the ex ante method retains the assumed 62.5 percent average cooling load and simply reduced full load hours by 813. The ex post analysis method produced a 184 hour reduction in weighted average full load hours, significantly less than the ex ante reduction of 813 full load hours.

The additional 6,589 annual kWh savings that was incorrectly recorded for this measure further reduced the realization rate by 1.17 percent.

Measure 3: Interior Lighting

Sources of uncertainty regarding these calculations stemmed from assumptions regarding operating hours and total wattages for the fixtures.

DNV KEMA's lower ex post savings estimate for EEM3 (81.3 percent realization rate) was primarily due the lower operating hours for fixtures controlled by occupancy sensors, the claimed lighting fixture, lighting control, and vending machine control installations that were not performed, the lower operating hours for all City Hall lighting fixtures.

DNV KEMA's slightly higher ex post savings estimate for maximum demand reduction (27.1 kW versus 21.8 kW) was primarily due to the additional fixture retrofits that were performed the City Hall (6.10 kW). The 8 fixture retrofits that were planned but not implemented accounted for a loss of 0.32 kW of demand reduction while another 0.50 kW was due to small differences in existing fixture wattages at the gym/ teen center.

Ex Post Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

Table 91 displays the first year savings used to calculate the Baseline 1 and Baseline 2 life-cycle savings. Table 91 12 also lists the effective and remaining useful lives of each measure. Table 92 presents the electrical energy, electrical demand, and natural gas energy savings according to Baseline 1 conditions for each year the measure is in place up to the end of the measure's EUL. Table 93 presents the yearly life-cycle savings values according to Baseline 2 conditions.

Table 91: Values Used in Ex Post Life-cycle Savings Calculations

Measure	Early Replacement			Expected Replacement			EUL (years)	RUL (years)
	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)		
EEM1- Package RTUs	6,212	7.55	-	1,001	1.44	-	15	1
EEM2- Building Automation Control	58,709	0	-	58,709	-	-	15	N/A
EEM3- Interior Lighting	98,420	27.08	-	98,420	27.08	-	15	1
Total	163,341	34.63	-	158,130	28.52	-	-	-

Source: DNV KEMA analysis

Table 92: Baseline 1 Life-cycle Savings

Life-cycle Year	Calendar Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	163,341	34.63	-
2	2013	163,341	34.63	-
3	2014	163,341	34.63	-
4	2015	163,341	34.63	-
5	2016	163,341	34.63	-
6	2017	163,341	34.63	-
7	2018	163,341	34.63	-
8	2019	163,341	34.63	-

Life-cycle Year	Calendar Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
9	2020	163,341	34.63	-
10	2021	163,341	34.63	-
11	2022	163,341	34.63	-
12	2023	163,341	34.63	-
13	2024	163,341	34.63	-
14	2025	163,341	34.63	-
15	2026	163,341	34.63	-
Life-cycle Total		2,450,115 kWh	519.4 kW-years	0 Therms

Source: DNV KEMA analysis

Table 93: Baseline 2 Life-cycle Savings

Life-cycle Year	Calendar Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	163,342	34.63	-
2	2013	158,130	28.52	-
3	2014	158,130	28.52	-
4	2015	158,130	28.52	-
5	2016	158,130	28.52	-
6	2017	158,130	28.52	-
7	2018	158,130	28.52	-
8	2019	158,130	28.52	-
9	2020	158,130	28.52	-
10	2021	158,130	28.52	-
11	2022	158,130	28.52	-
12	2023	158,130	28.52	-
13	2024	158,130	28.52	-
14	2025	158,130	28.52	-
15	2026	158,130	28.52	-
Life-cycle	Total	2,377,162 kWh	433.9 kW-years	0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Burlingame, City of (CBG-09-042)

Site Summary

The city of Burlingame conducted lighting retrofits at a total of four facilities and a set of street lights. The facilities included the Burlingame Police Station, the Donnely Parking Garage, Burlington Corp Yard, Fire Station #36, and street lights along California Drive from Broadway to Peninsula Ave. The comprehensive lighting retrofits included installing new fixtures, new bulbs, and occupancy sensors. The Burlington Police Station, Burlington Corp Yard, and Donnely Parking garage underwent full lighting retrofits of all the interior and exterior lighting fixtures, while Fire Station #36 conducted lighting retrofits for only one portion of the building. An additional measure, lighting controls at the library stack area, is listed in the database with no associated savings. This measure was not identified by the site contact.

The bulk of the retrofit consisted of replacing old T12 and T8 fixtures with new low wattage T8 fixtures, replacing older ballasts with new more efficient ballasts, installing new wall-mounted occupancy sensors where applicable, and installing more efficient streetlighting. In total, 71 streetlighting fixtures and 894 building lighting fixtures were retrofitted with 278 fixtures placed on occupancy sensors.

Ex ante and ex post savings for the lighting retrofit are provided in Table 94 below. Ex ante savings were collected from the EECBG database and were corroborated by the savings listed in the implementer's ex ante analysis. Ex post savings were calculated from project files and from data collected during the on-site verification. The collected data was analyzed to yield an overall electric energy savings of 110 percent and zero natural gas savings when compared to the estimated ex ante savings.

Table 94: Energy Savings Summary

Building	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
Corp Yard - Interior Lighting	61,847	Not reported	0.0	68,376	17.0	0.0	110.6%	N/A
Police Station - Interior Lighting	86,563	Not reported	0.0	101,830	11.2	0.0	117.6%	N/A
Fire Station - Interior Lighting	4,212	Not reported	0.0	3,432	1.1	0.0	81.5%	N/A
Donnely Parking Garage - Lighting	51,792	Not reported	0.0	41,530	8.3	0.0	80.2%	N/A
Streetlighting	44,999	Not reported	0.0	47,760		0.0	106.1%	N/A
Totals	249,413 kWh			262,928 kWh	37.6		105.4%	

Source: DNV KEMA analysis

The project saved more than the claimed savings in the ex ante analysis primarily because the savings in calculations used different baseline fixture wattages. Thus, both the baseline and newly installed fixture wattages were higher, resulting in more savings. Furthermore, the majority of the installed fixtures were verified during the on-site visit, so the specified number of fixtures was accepted to be accurate.

Life-cycle savings for the EEMs were calculated on the basis of EUL estimates from the California DEER. The DEER EULs for the lighting retrofit and occupancy sensor components of the project were 15 and 8 years respectively. The typical EUL for streetlighting is also 15 years.

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment is exceeded

As the buildings involved in the lighting retrofits were already code compliant, the Baseline 1 and Baseline 2 savings for this project were the same. Table 95 below summarizes the life-cycle savings relative to each of these baselines.

Table 95: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW years)	Natural Gas Energy Savings (Therms)
Baseline 1	3,840,502	564	0.0
Baseline 2	3,840,502	564	0.0

Source: DNV KEMA analysis

Project Description

Burlington Corp Yard: The Burlington Corp Yard completed a comprehensive lighting retrofit of their office building, garages, and shops. According to the ex ante documentation, the original plan was to retrofit 409 fixtures and install 35 wall mounted occupancy sensors. One hundred 94 of the retrofit fixtures were projected to be occupancy sensor controlled. The actual project included 411 fixtures, of which 385 fixtures were confirmed during the on-site verification. Not all of the fixtures could be verified because of accessibility issues and time constraints. Since the fixtures that were verified matched with the documented fixtures, the unverified fixtures were also assumed to be installed.

Police Station: The Burlington Police Station completed a comprehensive lighting retrofit of their office building and garage. According to the ex ante documentation, the original plan was to retrofit 316 fixtures and install 22 wall mounted occupancy sensors. Seventy-two of the retrofit fixtures were projected to be occupancy sensor controlled. Of the 318 fixtures, 221 were confirmed during the on-site verification. Not all of the fixtures could be verified because of accessibility issues and time constraints. Since the majority of the fixtures that were verified matched with the documented fixtures, the unverified fixtures were also assumed to be installed.

Fire Station #36: Burlington Fire Station #36 completed a lighting retrofit of one section of the facility's offices. According to the ex ante documentation, the original plan was to retrofit 25 fixtures. All 25 fixtures were confirmed during the on-site verification.

Donnely Parking Garage: The Donnely Parking Garage completed a lighting retrofit of the garage facilities. According to the ex ante documentation, the original plan was to retrofit 71 fixtures. Some of the fixtures were on 24 hours/day, while others controlled by photocells were on for approximately 12 hours/day. Of the 71 fixtures, 56 were confirmed during the on-site verification. Not all of the fixtures could be verified because of accessibility issues and time constraints. Since the majority of the fixtures that were verified matched with the documented fixtures, the unverified fixtures were also assumed to be installed.

Streetlighting: Multiple lighting fixtures were retrofitted along California Drive between Broadway and Peninsula Ave. According to the ex ante documentation, 71 HPS fixtures were to be replaced with 71 LED fixtures. All of the street lights were controlled by photocell and operated for approximately 12 hours/day. All 71 fixtures were confirmed during the on-site verification.

Ex Ante Savings

San Mateo County Energy Watch conducted the ex ante savings analysis using a spreadsheet calculation. In general, for any group of fixtures, savings were calculated as:

$$kWh_{saved} = \frac{n}{1000}(W_{bl}h_{bl} - W_{ins}h_{ins})$$

Where:

n = Number of affected fixtures

W_{bl} = Baseline Fixture Wattage [W]

h_{bl} = Baseline Operating Hours [h]

W_{ins} = Installed Fixture Wattage [W]

h_{ins} = Installed Operating Hours (potentially adjusted for occupancy sensors) [h]

1,000 = [W/kW]

Savings from all affected fixture groups were then summed to estimate gross project savings.

Project Evaluation

A DNV KEMA engineer visited the facility on December 12th, 2011 to verify the installation of each fixture and occupancy sensor, and gather facility lighting schedule data to assist in assessing energy savings. During verification of the 894 total new fixtures of which 266 were attached to occupancy sensors, 758 fixtures were identified, of which 244were controlled by occupancy sensors. Not all of the newly installed fixtures could be verified due to accessibility issues and time constraints.

The operating hours documented in the ex ante analysis were confirmed during the on-site verification with the site contact. The fixtures controlled by photocells were assumed to operate 12 hours/day for a total of 4,380 annual operating hours. In order to account for the additional savings due to the installation of occupancy sensors, the operating hours for effected fixtures was scaled by a factor of $\frac{1}{(1-.3)}$, which follows from the standard practice assumption that occupancy sensors yield a 30 percent reduction in lighting time-of-use.[26]

26 2010 NEEP Mid-Atlantic Technical Reference Manual Version 1.1 page 83.

Savings with respect to the pre-existing equipment baseline were calculated using the same general methodology as the ex ante analysis. For a given group of lights, the savings were calculated as:

$$kWh_{saved} = hours\ x\ \frac{n}{1000}(W_{bl}h_{bl} - W_{ins}h_{ins})$$

Where:

hours = Operating Hours

n = Number of affected fixtures

W_{bl} = Baseline Fixture Wattage [W]

h_{bl} = Baseline Operating Hours [h]

W_{ins} = Installed Fixture Wattage [W]

h_{ins} = Installed Operating Hours (potentially adjusted for occupancy sensors) [h]

1,000 = [W/kW]

Savings Results

The project achieved annual energy savings of 262,928 kWh and 37.6 kW in demand savings compared to the reported ex ante savings of 249,416 kWh. Table 94 provides a breakdown of the ex post energy savings along with the ex ante energy savings for comparison.

Discussion

The project had different savings than estimated in the ex ante analysis for a few key reasons. First, the ex ante analysis used different baseline fixture wattages, resulting in lower wattages and higher savings. For example, the ex ante calculations used a fixture wattage of 400W for a 400W MH bulb, when the fixture wattage should actually be 458W for a 400W MH bulb. Second, a few of the verified fixtures were not found during the on-site visit, so the corresponding savings were deducted. Third, the ex ante analysis assumed the operating hours for photocell controlled fixtures to be 14 hours/day when they should be 12 hours/day, resulting in less savings.

The ex ante savings provided by the Energy Commission updates to the EECBG database did not entirely match the savings provided by the site contact. The savings approach used by the site contact was structured similar to the ex post savings approach. However, the methodology and assumptions used in the ex ante savings cannot be confirmed due to lack of the ex ante savings documentation.

Ex Post Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the

control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

According to the feasibility study for Burlingame, the interior lighting for the Corporate Yard, Police Station, and Fire Station was approximately 10 years old, while the parking lot lighting was approximately 20 years old. The streetlighting age was unknown but assumed to be at least twenty years old. The EUL of both the interior lighting and streetlighting is 15 years. Table 96 summarizes the energy savings and life-cycle parameters used in the life-cycle savings calculations. Because occupancy sensors have a shorter lifetime than other lighting fixture, the savings due to occupancy sensors are broken out.

Table 96: Values Used in Life-cycle Savings Calculations

Measure	Early Replacement		Expected Replacement		EUL (years)
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)	
Lighting without Occupancy Sensors	248,154	0.0	248,154	0.0	15
Occupancy sensors only	14,774	0.0	14,774	0.0	8

Source: DNV KEMA analysis

Table 97 below provides life-cycle savings for the project relative to Baseline 1 on a year-by-year basis through the EUL of the longest lived measure. Under this baseline, energy savings were presumed to occur relative to the pre-existing equipment for the duration of each measure's life. For this project, the life-cycle savings estimates relative to Baseline 2 (dual baseline) are the same as the life-cycle savings relative to Baseline 1 as the pre-retrofit conditions were already code compliant.

Table 97: Baseline 1 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	262,928	37.6	0.0
2	2012	262,928	37.6	0.0
3	2013	262,928	37.6	0.0
4	2014	262,928	37.6	0.0

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
5	2015	262,928	37.6	0.0
6	2016	262,928	37.6	0.0
7	2017	262,928	37.6	0.0
8	2018	262,928	37.6	0.0
9	2019	248,154	37.6	0.0
10	2020	248,154	37.6	0.0
11	2021	248,154	37.6	0.0
12	2022	248,154	37.6	0.0
13	2023	248,154	37.6	0.0
14	2024	248,154	37.6	0.0
15	2025	248,154	37.6	0.0
16	2026	0	0	0.0
Total		3,840,502 kWh	564 kW-Years	0.0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Laguna Beach, City of (CBG-09-057-A)

Site Summary

This project involved the relamping or replacement of 755 fixtures throughout seven Laguna Beach city buildings and the installation of 21 new packaged RTUs totaling 72 tons of cooling. The following areas were included in the retrofit: Fire Station #1, Fire Station #2, City Hall, Corporate Yard, Mermaid St. Parking Garage, Lang Park, and the Glenneyre Parking Garage. Typical operating hours for City Hall and Lang Park are 7 a.m. to 5 p.m., Monday through Friday. The two fire stations and the parking garages operate 24 hours per day.

The implemented measures at the Laguna Beach buildings included (EEM1) retrofit lighting fixtures and (EEM2) high efficiency packaged HVAC units. Table 98 below summarizes the ex post and ex ante savings estimates for each measure.

Table 98: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 – Retrofit indoor light fixtures	127,639	33.0	N/A	127,639	33.0	N/A	100%	N/A
EEM2 –High efficiency packaged HVAC units	39,026	31.0	N/A	36,788	50.5	0	94%	N/A
Total	166,665	64.0	0	164,427	83.5	0	99%	N/A

Source: DNV KEMA analysis

There is not a significant difference between the ex post savings and those estimated in the ex ante calculations. Due to the large number of fixtures, buildings, and space types, the evaluation team inspected a portion of the light fixtures installed as part of this project, obtained the final installed lighting inventory, and inspected the installation of the high efficiency HVAC units and HVAC savings calculation methodology.

Savings for EEM1 were confirmed after the site inspection found all sample fixtures were accurately recorded in the lighting inventory. Annual hours of operation for each of the building and space type were also confirmed with site contacts.

Savings for EEM2 were reduced due to a small reduction in the annual full-load hour loading assumption. All units were installed as detailed in the program documentation and

were high efficiency units with SEER ratings between 14.0 and 15.0, which is well above Title 24 requirements.

In addition to the first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For the lighting fixture retrofit the baselines are identical. The existing HVAC equipment had an estimated two years of RUL and as such for Baseline 2, the existing equipment efficiency was used for the first two years while Title 24 minimum efficiency units was used for the remaining 13 years.

For lighting retrofits (EEM1) and HVAC retrofits (EEM2), DEER provides an EUL of 15 years.

Table 99: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline 1	2,466,405	83.5	N/A
Baseline 2	2,064,536	33.0	N/A

Source: DNV KEMA analysis

Project Description

This project involved the installation of twenty one new packaged HVAC units and the relamping or replacement of 755 fixtures throughout seven Laguna Beach buildings. The following areas were included in the retrofit: Fire Station #1, Fire Station #2, City Hall, Corporate Yard, Mermaid St Parking Garage, Lang Park and the Glenneyre Parking Garage.

Measure 1 – Retrofit Light Fixtures

EEM1 consisted of a complete lighting retrofit for all seven buildings involved in the project. A room-by-room lighting survey was completed, which documented baseline as well as replacement fixture types for all 755 fixtures replaced as part of this project. The vast majority of the line items involve the relamping of standard ballast factor 32W T8 fixtures with 28WT8 fixtures and low ballast factor high-efficiency ballasts. Additional measures included replacing incandescent exit signs with new LED fixtures and the installation of 15W CFL R30 bulbs.

Savings were calculated line-by-line using the following algorithm:

$$Annual\ savings\ (kWh) = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Pre-retrofit annual hours of operation for usage group
PostRunHrs	= Postretrofit annual hours of operation for usage group

HVAC interactive effects were not accounted for in the ex ante savings estimates, and are also not included in the ex post analysis.

Measure 2–High Efficiency Packaged HVAC Units

EEM2 consisted of installing new packaged HVAC units in city hall. Site inspections confirmed that all 21 units listed in the ex ante savings calculations were installed.

Project Evaluation

An ERS engineer visited the facility on May 25, 2012, to verify the installation of each measure, verify the hours of operation with site staff, and verify that equipment specifications met those listed in the program documentation.

Measure 1 –Retrofit Light Fixtures

On-site verification activities confirmed that the lighting measure was installed at seven of the buildings listed in the program documentation. An updated lighting survey and set of savings calculations was obtained from the site contact during the visit. This survey listed room-by-room baseline and postinstallation fixture quantities and fixture types. ERS verified the installation of fixtures in each of the buildings included in this project.

For each major fixture type, the evaluation team verified that the lamps and ballasts installed matched those listed in the lighting survey. The evaluation team did not find any major discrepancies in the survey provided by the site contact.

The photos in Figure 33 and Figure 34 show the light fixtures and ballasts surveyed as part of the inspection process.

Figure 33: Two-lamp 28W T8 Fixture

Photo Credit: DNV KEMA

Figure 34: Low Ballast Factor T8 Ballast

Photo Credit: DNV KEMA

Measure 2 –High Efficiency Packaged HVAC Units

On-site verification activities determined that all 21 rooftop packaged HVAC units described in the ex ante calculations were installed as part of this measure. The 21 units installed as part of this project serve the entire cooling load of city hall. The installed units' seasonal energy efficiency ratio (SEER) vary between 14.0 and 15.0. The program documents did not list the type of efficiency of the replaced units; however, site contacts said that the new units have exactly the same tonnage as those that were replaced.

The revised annual savings analysis was performed using a revised full-load hour calculation based on the California standard weather file for CZ06. Savings calculations were made using the standard EFLH spreadsheet. The spreadsheet calculates total annual full load hours of operation by assuming a linear cooling load from 0 to 100 percent between CZ06 outdoor air temperatures of 65F and 85F.

The photo in Figure 35 below shows a sample of the HVAC units surveyed as part of the inspection process.

Figure 35: City Hall North Well HVAX Units

Photo Credit: DNV KEMA

Savings Results

Taking into account both EEMs, the Laguna Beach project resulted in 164,427 kWh of annual gross energy savings and peak demand savings of 83.5 kW. A breakdown of savings by individual measure is presented in Table 98 at the beginning of this report. The ex ante savings estimates, which were acquired from the program's monthly status reports, are also provided as a point of reference.

Discussion

Measure 1 – Retrofit Light Fixtures

On-site verification activities found that the lighting measure was exactly as detailed in the program documentation. The evaluation team verified the installation of fixtures in each of the

seven buildings included in the lighting retrofit. Hence, there is no difference between ex post and ex ante energy savings.

Measure 2 –High Efficiency Packaged HVAC Units

The revised annual savings analysis was performed using estimated annual full-load hours of operation based on the California standard weather file for CZ06. The SEER for all units was verified based on nameplate information gathered on-site. Calculations were made using the standard EFLH spreadsheet. The EFLH spreadsheet calculated 729 full load hours for the system while the Ex ante calculations assumed 997 full load hours of operation. This difference in cooling load is the source of the savings discrepancy.

Ex Post Life-cycle Savings

Energy savings were calculated relative to two established baselines referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation, and it takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assume the pre-existing equipment would have operated for the full EUL of the new equipment regardless of whether the existing equipment was at the end of its useful life. In contrast, Baseline 2 uses the pre-existing equipment as the measure baseline until the end of the existing equipment's RUL.After the remaining useful-life period and up until the end of the EUL of the installed measure, an expected replacement baseline is used. This baseline considers minimally code-compliant conditions or standard practice where no code is applicable.

Table 100 provides the annual energy savings estimates that fed into the life-cycle savings calculations (same as those in Table 98), as well as the EULs for each measure.

Table 100: Values Used in Life-cycle Savings Calculations by Measure

Measure	Early Replacement		Expected Replacement		EUL (Years)	RUL (Years)
	Electric Energy (kWh)	Peak Demand (kW)	Electric Energy (kWh)	Peak Demand (kW)		
EEM1 - Retrofit indoor light fixtures	127,639	127,639	127,639	127,639	15	N/A
EEM2 – High efficiency packaged HVAC units	36,788	50.5	5,875	8.1	15	2

Source: DNV KEMA analysis

Table 100 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 101: Life-cycle Savings

Life-cycle	Year	Baseline 1 Electric Energy Savings (kWh/yr)	Baseline 2 Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	164,427	164,427	83.5	N/A
2	2012	164,427	164,427	83.5	N/A
3	2013	164,427	133,514	33.0	N/A
4	2014	164,427	133,514	33.0	N/A
5	2015	164,427	133,514	33.0	N/A
6	2016	164,427	133,514	33.0	N/A
7	2017	164,427	133,514	33.0	N/A
8	2018	164,427	133,514	33.0	N/A
9	2019	164,427	133,514	33.0	N/A
10	2020	164,427	133,514	33.0	N/A
11	2021	164,427	133,514	33.0	N/A
12	2022	164,427	133,514	33.0	N/A
13	2023	164,427	133,514	33.0	N/A
14	2024	164,427	133,514	33.0	N/A
15	2025	164,427	133,514	33.0	N/A
Total		2,466,405	2,064,536		

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Colma, Town of (CBG-09-088)

Site Summary

This streetlight project consisted of replacing 32 HPS fixtures (150 W) with 32 LED fixtures (106 W) and replacing 30 decorative HPS fixtures (70 W) with 30 decorative Induction fixtures (40 W). Annual operating hours for all fixtures (photocell controlled) were assumed to be 4,380 as provided by the city's calculations. Installation verification was performed by visually verifying all of the 62 new lighting fixtures. Of the 32 verified LED fixtures, all fixtures were found to have been retrofitted with the specified wattages. The 30 induction fixtures were verified to have been installed, but the wattages could not be confirmed because there was no bulb access. No modifications of the city's tracking quantities or fixture wattages were made based on the verification sample.

Table 102: Savings and Realization Rate

Ex Ante Savings	Ex Post Savings	Realization Rate
14,368 kWh	14,927 kWh	103.9%

Source: DNV KEMA analysis

Table 103: City Tracking Spreadsheet Retrofit Claims

Pre-Existing Fixtures			Installed Fixtures			
Type	Nominal Wattage	Functional Wattage	Type	Nominal Wattage	Functional Wattage	Fixture Count
HPS	150	180	LED	106	111	32
HPS	70	84	Induction	40	45	30

Source: DNV KEMA analysis

Table 104: Verified Sample Savings

Pre-Existing Fixtures		Installed Fixtures				
Type	Nominal Wattage	Type	Nominal Wattage	Verified Fixture Count	% of Verification Sample Properly Installed	Average Functional Wattage of Fixtures with Discrepancies
HPS	150	LED	106	32	100%	-
HPS	70	Induction	40	30	100%	-
Total					100%	

Source: DNV KEMA analysis

Table 105: Verification Revised Fixture Table

Pre-Existing Fixtures			Installed Fixtures					
Type	Nominal Wattage	Functional Wattage	Type	Nominal Wattage	Revised Functional Wattage Based on Verification	Fixture Count	Verified Demand Reduction (kW)	Verified Energy Savings (kWh)
HPS	150	180	LED	106	111	32	2.21	9671
HPS	70	84	Induction	40	45	30	1.17	5125
Total							3.38	14,796

Source: DNV KEMA analysis

Figure 36: Verification Sample Area Map

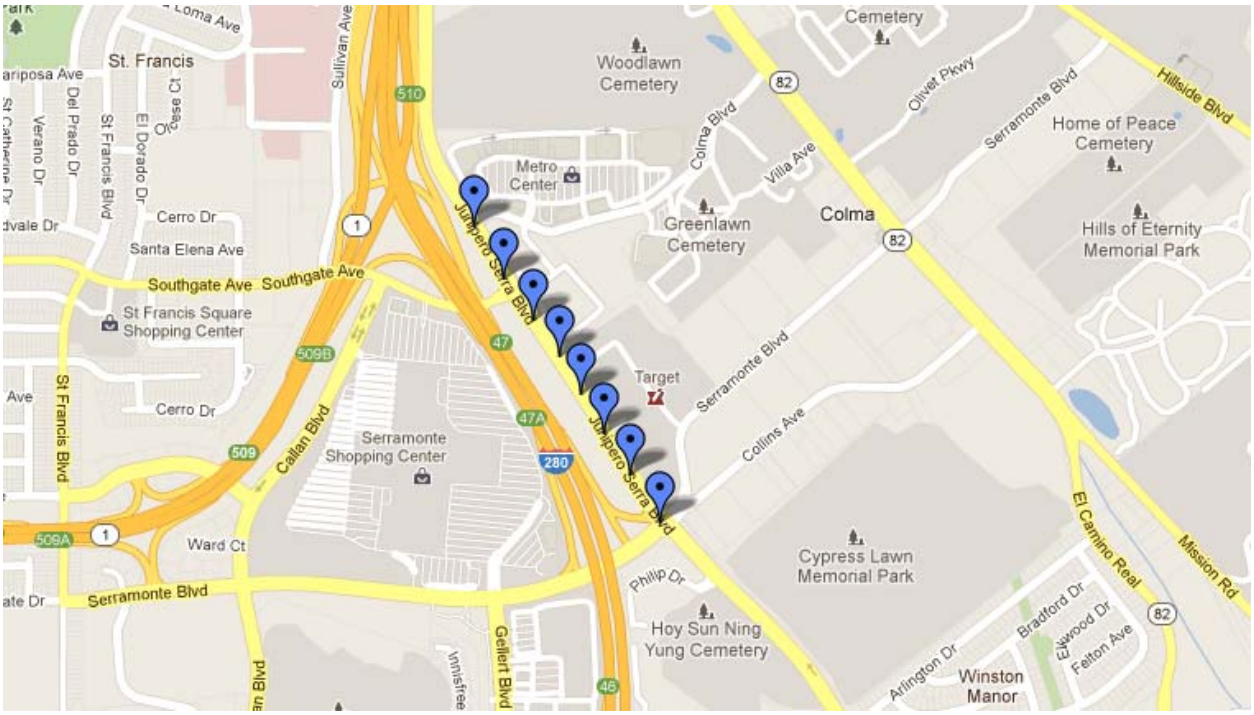


Photo Credit: DNV KEMA

Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EULof the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable. According to the decision maker survey completed with the site contact , the pre-existing streetlighting was installed seven years ago with a EUL of 15 years.

The tables below provide life-cycle savings for the project relative to Baseline 1 on a year-by-year basis through the EUL of the longest lived measure. Under this baseline, energy savings were presumed to occur relative to the pre-existing equipment for the duration of each measure's life. For this project, the life-cycle savings estimates relative to Baseline 2 (dual baseline) are the same as the life-cycle savings relative to Baseline 1.

Table 106: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Peak Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	14,796	NA	0
2	2012	14,796	NA	0
3	2013	14,796	NA	0
4	2014	14,796	NA	0
5	2015	14,796	NA	0
6	2016	14,796	NA	0
7	2017	14,796	NA	0
8	2018	14,796	NA	0
9	2019	14,796	NA	0
10	2020	14,796	NA	0
11	2021	14,796	NA	0
12	2022	14,796	NA	0
13	2023	14,796	NA	0
14	2024	14,796	NA	0
15	2025	14,796	NA	0
16	2026	0	0	0
Total		221,940 kWh		0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Fort Bragg, City of (CBG-09-090)

Site Summary

This project involved the retrofit of two wastewater treatment pumps with new motors, pumps, and variable frequency control systems and the replacement of 89 fixtures throughout three Fort Bragg City buildings. The following areas were included in the retrofit: the wastewater treatment plant, the guest house museum, and city hall. However, only the two wastewater treatment pumps were funded with the EECBG grant. The lighting retrofit projects were cost share only, funded by the City of Fort Bragg.

The implemented measures in Fort Bragg included a lighting retrofit (EEM1) and VFD pump retrofit (EEM2). Table 107 below summarizes the ex post and ex ante savings estimates for this project.

Table 107: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 – Install VFD on wastewater pump	13,910	N/A	N/A	27,682	4.96	N/A	199%	N/A
EEM2 – Retrofit light fixtures	23,563	N/A	N/A	15,353	4.37	N/A	65%	N/A
Total	37,473	N/A	N/A	43,035	9.33	N/A	115%	N/A

Source: DNV KEMA analysis

Energy savings for EEM1 were adjusted significantly higher after spot measurements showed that the electrical draw of the system was much lower at part-load speeds than what was anticipated in the ex ante savings calculations. Data loggers were deployed on the new pumps for 3 weeks to determine average usage patterns and part-load profile.

During the site inspection, ERS found significant differences between the lighting survey submitted in the program documents for EEM2 and the installed fixtures. The evaluation team inspected all fixtures installed as part of this measure. Three of the 15 lighting line items in the lighting survey were not installed. Logged data and interviews with site contacts led to significant adjustments to ex post annual hours of operation for two groups of fixtures. ERS deployed lighting meters on the high bay fluorescent fixtures, which comprised 24 percent of the savings for EEM2. The metered data for this area showed significantly lower annual hours of operation than the figures listed in the program documentation. Site contacts and museum

schedules showed the annual hours of operation for the guest house were lower than those figures used in the ex ante savings calculations.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings (see Table 108) were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For both the lighting fixture retrofit and VFD pump measure, baselines 1 & 2 are identical because the pre-retrofit conditions are identical to what is considered standard practice or minimally code compliant.

For VFD pump retrofits (EEM1), DEER provides an EUL of 15 years.

For lighting retrofits (EEM2), DEER provides an EUL of 15 years.

Table 108: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline 1 & 2	645,525	9.33	0.0

Source: DNV KEMA analysis

Project Description

This project involved the replacement of 89 fixtures throughout three buildings in the city of Fort Bragg and the installation of two new 20 hp variable speed wastewater treatment pumps. The following areas were included in the retrofit: the wastewater treatment plant, the guest house museum, and city hall.

Measure 1 – Install VFD on Wastewater Pump

EEM1 involved the replacement of a wastewater recirculation pump. Two end-of-service-life pumps were replaced with new motors, pumps, and VFDs. The new control system allows the site to reduce circulation rates during off-peak periods.

Measure 2 – Retrofit Indoor Light Fixtures

EEM2 consisted of a complete lighting retrofit of the guest house museum and city hall, as well as the installation of new high bay fluorescent fixtures in the wastewater treatment plant. A room-by-room lighting survey was completed that documented baseline as well as replacement

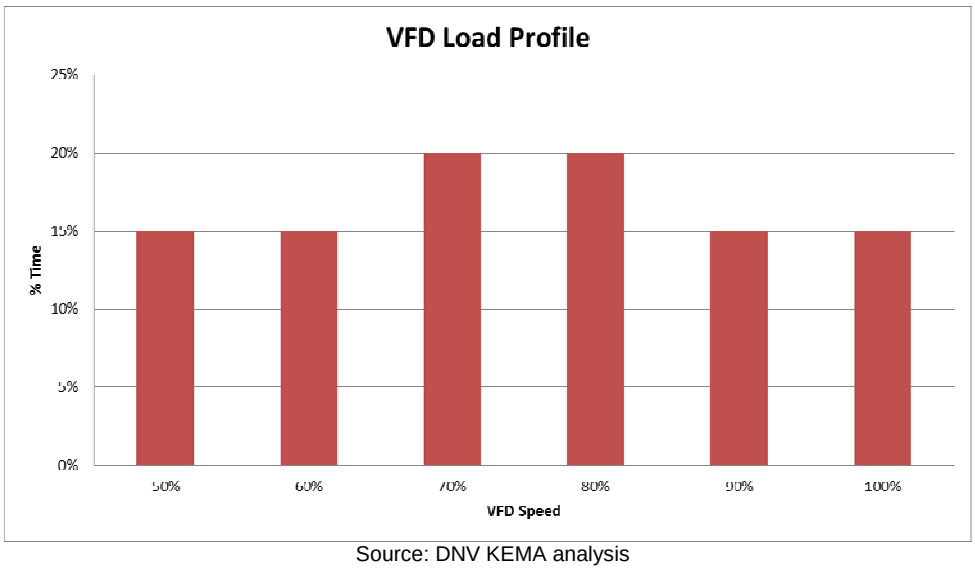
fixture types for all 89 fixtures replaced as part of this project. This survey was included in the program documentation provided to the evaluation team.

Ex Ante Savings

Measure 1 – Install VFD on Wastewater Pump

Savings were calculated using the ABB Pump Save tool.[27] The tool assumed a standard load profile detailed in Figure 37. The tool also assumed a pump efficiency of 84 percent, a motor efficiency of 91 percent, and 8760 annual hours of operation.

Figure 37: Ex Ante Estimated Pump Load Profile



Source: DNV KEMA analysis

Measure 2 – Retrofit Indoor Light Fixtures

Savings were calculated line-by-line using the following algorithm:

Where,

= Baseline fixture wattage (kW)

= Baseline fixture quantity (#)

= Retrofit fixture wattage (kW)

---

27 The calculations were performed with ABB's PumpSave tool, which is publically available online. ABB is a private company. http://www.abb.com/product/ap/seitp322/24b03100d005c31ac1256e040043f4c1.aspx?country=US.

RFQ = Retrofit fixture quantity (#)

$BaseRunHrs$ = Preretrofit annual hours of operation for usage group

$PostRunHrs$ = Postretrofit annual hours of operation for usage group (assumed to be the same as no measures involved the installation of occupancy sensors)

Updated total lighting ex ante savings were provided in the 9/17/12 tracking data. HVAC interactive effects were not accounted for in the ex ante savings estimates, and therefore not included in the ex post analysis.

Project Evaluation

An ERS engineer visited the facility on February 14, 2012 and March 6, 2012 to verify the installation of each measure, verify the hours of operation with site staff, and install data logging equipment on the variable speed pumps and high bay lighting system. Table 109 below contains a summary of all monitoring equipment that was installed during the initial site visit.

Table 109: Monitoring Details

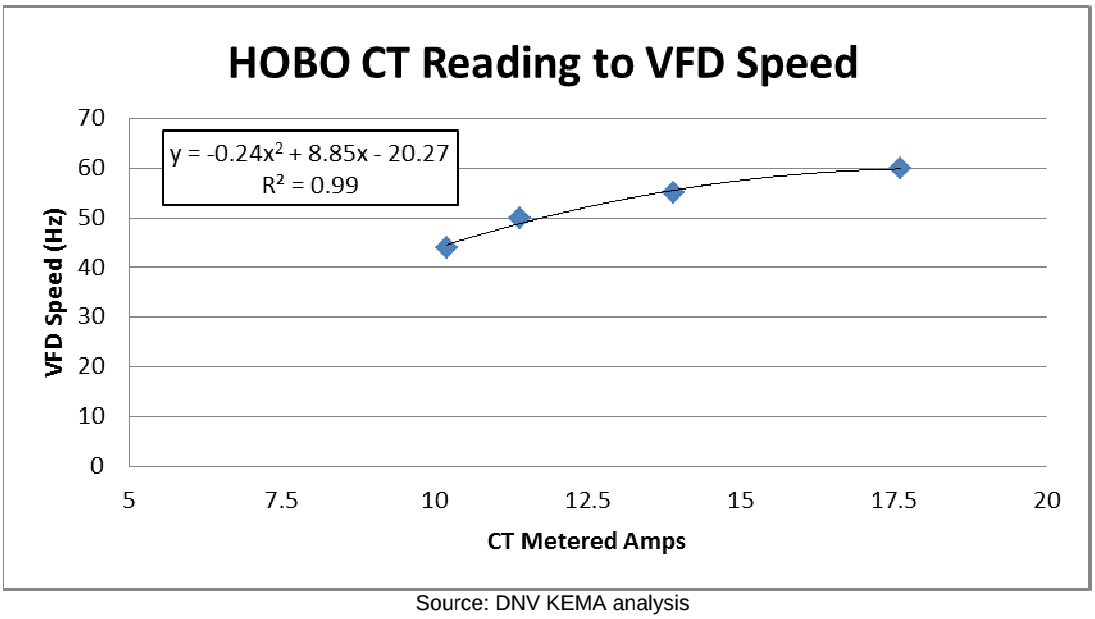
Monitored Equipment	Logger Type	Measurement Type	Measurement Interval	Duration
Wastewater treatment - pump #1	HOBO U12 – with 50 amp CT	Amperage	2 minutes	21 days
Wastewater treatment - pump #2	HOBO U12 – with 50 amp CT	Amperage	2 minutes	21 days
Wastewater treatment - high bay light fixtures	HOBO U12-12 light level	Light Level	2 minutes	21 days

Source: DNV KEMA analysis

Measure 1 – Install VFD on Wastewater Pump

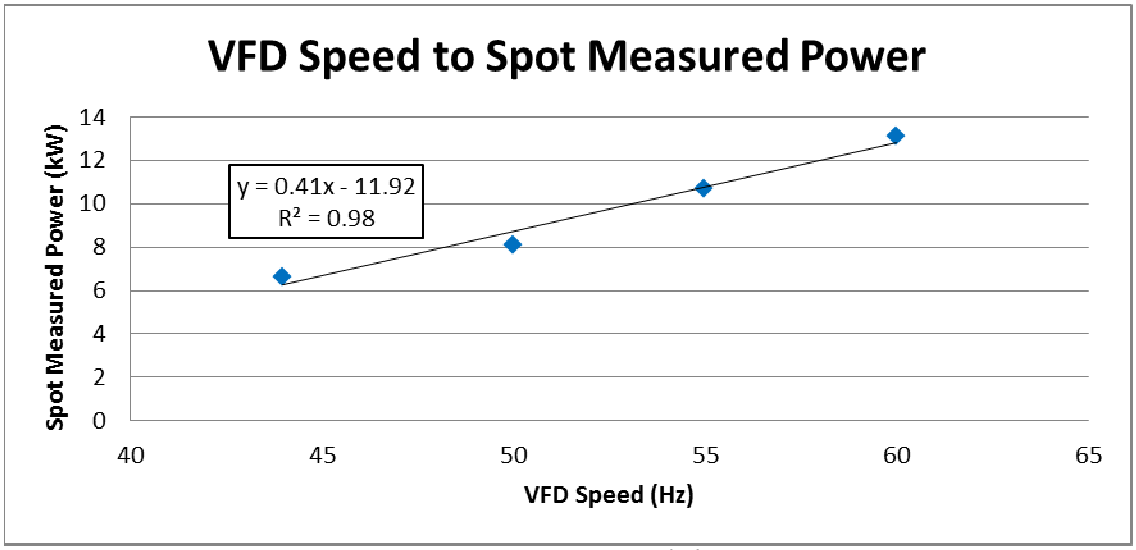
On-site verification activities confirmed that the pumps, motors, and variable speed controls were installed as described in the program documentation. The evaluation team deployed data logging equipment on both pumps for a period of 3 weeks. In addition to logged data, the evaluation team performed spot power measurements throughout the speed range of the pumps. The results of the spot measurements and correlations are presented in Figure 38and Figure 39.

Figure 38: Amperage Readings to Pump Speed Correlation



Source: DNV KEMA analysis

Figure 39: Pump Speed to Spot Measured Pump (kW)



Source: DNV KEMA analysis

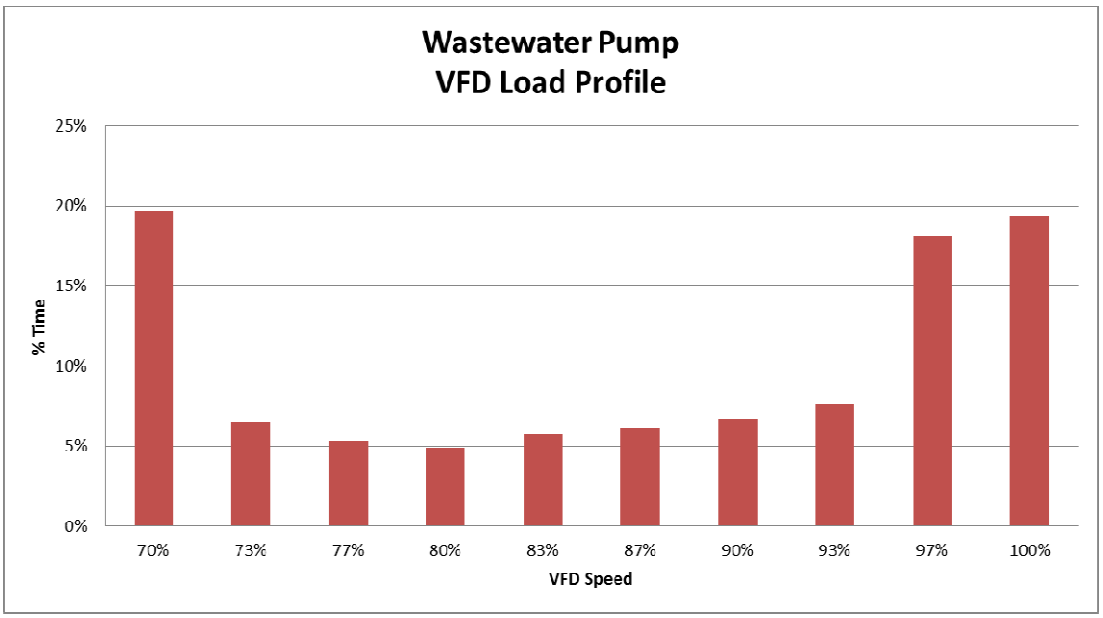
The metered data, presented in Figure 40, shows a consistent daily pattern with morning and evening periods of high use. These results are consistent with descriptions from the site contacts and the information presented in the program documentation. The VFD pumps were set to a minimum speed of 43 Hz. The pumps hovered around this minimum through most of the early morning off-peak hours. The logged data was used to develop the annual load profile, shown in Figure 41, which was the basis of the annual savings calculations.

Figure 40: Metered Pump Speed

Ave Speed (Hz) Weekday								
Hour	1	2	3	4	5	6	7	Average
0	44.5	45.0	50.2	46.7	48.3	47.0	45.9	46.8
1	43.6	44.3	46.4	45.5	45.6	44.6	44.5	44.9
2	43.0	43.3	45.0	44.5	44.6	44.1	43.4	44.0
3	43.0	43.1	44.1	44.1	44.4	43.5	43.3	43.7
4	43.0	43.0	43.9	44.2	43.7	43.4	43.0	43.5
5	43.1	43.5	44.4	44.6	44.7	43.7	43.0	43.9
6	43.9	44.1	46.3	47.0	47.1	43.4	43.0	45.1
7	49.0	48.2	51.5	52.4	51.7	45.2	43.8	49.0
8	55.3	51.2	56.1	56.3	55.4	51.1	50.9	54.0
9	58.4	55.9	58.6	56.8	58.6	56.9	57.7	57.7
10	57.9	57.0	59.0	58.7	59.1	58.4	59.3	58.6
11	55.9	58.3	59.0	58.8	58.0	58.6	58.8	58.2
12	55.6	55.9	58.4	58.2	57.6	55.7	57.8	57.0
13	54.1	55.1	56.8	57.0	55.1	55.5	57.0	55.8
14	50.0	53.3	56.0	55.2	54.1	55.4	50.6	53.5
15	50.0	51.3	52.6	54.9	50.0	53.6	52.9	52.2
16	51.1	51.2	55.6	53.9	53.3	50.6	53.6	52.7
17	53.7	53.6	57.7	55.8	55.1	56.3	55.7	55.4
18	56.0	57.0	59.3	58.6	57.9	58.3	57.6	57.8
19	57.1	58.6	59.0	58.3	58.3	58.6	58.0	58.3
20	56.2	58.2	58.0	58.5	58.1	57.2	56.3	57.5
21	54.1	57.9	57.0	57.5	56.7	55.1	55.3	56.2
22	50.5	55.1	54.5	55.2	53.8	53.0	52.0	53.4
23	47.3	53.3	50.4	51.9	51.0	49.7	47.9	50.2
Average	**50.7**	**51.4**	**53.3**	**53.1**	**52.6**	**52.4**	**51.3**	**52.1**

Source: DNV KEMA analysis

Figure 41: Metered Annual Pump Load Profile



Source: DNV KEMA analysis

Annual savings were modeled using pumping affinity law calculations calibrated to spot measured data. The part-load model was calibrated using spot measured kW and speed measurements. This calibration is shown in Figure **42**. Annual hours of operation were assumed to be 8760 hours per year and the system was assumed to operate using one pump at a time. The secondary pump operates as a backup and logged data did not show any periods when the two units were operational at the same time.

Figure 42: Annual Savings Calculations

Description	HP	Qty	Estimated Load	Efficiency	Demand kW	Total Demand kW
Circulation pump	20	1	72%	83.0%	12.9	12.9
Total		**1**				**12.9**

Existing Process Pumps Demand	12.9	kW

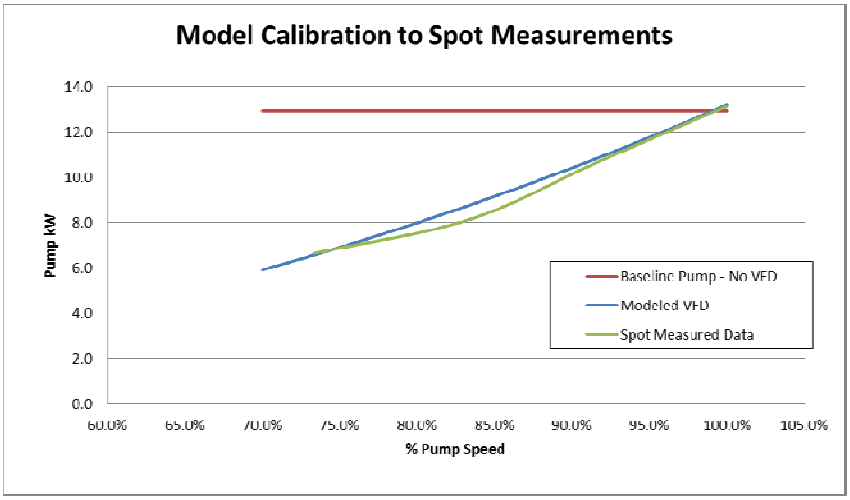
VFD Parameters	
Power-to-speed reduction exponent	2.3
Average VFD efficiency penalty	2.0%

Hours of Operation	8,760

Output Load Level	Metered Data %Time at Load	Baseline w/o VFD kW	Installed w/VFD kW	Baseline w/o VFD kWh	Installed w/VFD kWh	Energy Savings kWh
100.0%	19%	12.9	13.2	21,917	22,364	-447
96.7%	18%	12.9	12.2	20,505	19,387	1,118
93.3%	8%	12.9	11.3	8,596	7,510	1,086
90.0%	7%	12.9	10.4	7,580	6,102	1,478
86.7%	6%	12.9	9.6	6,975	5,158	1,817
83.3%	6%	12.9	8.8	6,486	4,391	2,095
80.0%	5%	12.9	8.0	5,516	3,407	2,109
76.7%	5%	12.9	7.3	6,051	3,396	2,655
73.3%	7%	12.9	6.6	7,394	3,755	3,639
70.0%	20%	12.9	5.9	22,359	10,226	12,133
	100%		**TOTALS**	**113,378**	**85,695**	**27,682**

Source: DNV KEMA analysis

Figure 43: Power-to-speed Reduction Exponent and Estimated Load Calibration



Source: DNV KEMA analysis

ERS determined demand savings for this measure by filtering the logged data for the 2 p.m.to 5 p.m. period on weekdays and input the demand period load profile into the Excel model of the system detailed above in Figure 43.

Measure 2 – Retrofit Indoor Light Fixtures

On-site verification activities confirmed that the lighting measure was installed. A full lighting survey was provided in the program documentation to the evaluation team. This survey listed room-by-room baseline and postinstallation fixture quantities and fixture types.

Interviews with site contacts and museum schedule documents revealed that the annual hours of operation for the guest house were slightly less than those used in the simplified savings calculations included in the program documentation. The guest house museum operates from 11 a.m. to 2 p.m. weekdays and 10 a.m. to 4 p.m. on weekends from June through October and from 11 a.m. to 2 p.m. Thursday to Sunday from November to May.

For each fixture type the evaluation team verified that the lamps and ballasts installed matched those listed in the lighting survey. The evaluation team found three line items that were not installed. The city hall storage areas were still equipped with incandescent fixtures, the guest house closet fixture was not replaced, and the high bay fixtures in the wastewater treatment plant were not equipped with occupancy sensors. Figure 44 details the adjustments to the lighting survey the evaluation team made following the site inspection. Figure 45 shows an example of the incandescent fixtures the evaluation team observed.

Figure 44: Lighting Survey Adjustments

ID	Space Name	kW Savings Change	kWh Savings Change	Description
1	City hall - Storage H_2O heater	-0.48	-1,196	Inspection found these fixtures were not replaced
2	Guest house - 1st floor / closet	-0.02	-41	Inspection found this fixture was not replaced
3	Wastewater - Sludge bay	0.00	-873	High bay fixtures were not equiped with occupancy sensors
Total		**-0.50**	**-2,110**	

Source: DNV KEMA analysis

Figure 45: City Hall – Remaining Incandescent Fixtures

Photo Credit: DNV KEMA

The evaluation team logged the lighting patterns of the high bay fixtures to more accurately determine annual hours of operation. Light loggers were deployed for 3 weeks to record standard operating procedures. The fixtures were installed in an ancillary shed, which is only occupied when solid waste is being processed. Figure 103 below summarizes the logged data averaged by weekday. The logged hours of operation were annualized and substituted for those values included in the program documentation. The evaluation team determined demand savings for this line item by sorting the logged data for the 2 p.m. to 5 p.m. period on weekdays.

Figure 46: High Bay Fixture Usage Pattern

% Time on Weekday								
Hour	1	2	3	4	5	6	7	Average
0	0%	0%	0%	0%	0%	0%	0%	0%
1	0%	0%	0%	0%	0%	0%	0%	0%
2	0%	0%	0%	0%	0%	0%	0%	0%
3	0%	0%	0%	0%	0%	0%	0%	0%
4	0%	0%	0%	0%	0%	0%	0%	0%
5	0%	0%	0%	0%	0%	0%	0%	0%
6	0%	0%	0%	0%	0%	0%	0%	0%
7	0%	31%	45%	26%	18%	0%	0%	17%
8	0%	50%	67%	34%	33%	0%	0%	25%
9	0%	50%	67%	33%	56%	0%	0%	28%
10	0%	50%	67%	33%	67%	0%	0%	30%
11	0%	50%	47%	33%	67%	0%	0%	27%
12	0%	50%	33%	33%	67%	0%	0%	25%
13	0%	50%	0%	33%	67%	0%	0%	20%
14	26%	50%	9%	33%	33%	0%	0%	20%
15	24%	10%	0%	4%	4%	0%	0%	6%
16	0%	0%	0%	0%	0%	0%	0%	0%
17	0%	0%	0%	0%	0%	0%	0%	0%
18	0%	0%	0%	0%	0%	0%	0%	0%
19	0%	0%	0%	0%	0%	0%	0%	0%
20	0%	0%	0%	0%	0%	0%	0%	0%
21	0%	0%	0%	0%	0%	0%	0%	0%
22	0%	0%	0%	0%	0%	0%	0%	0%
23	0%	0%	0%	0%	0%	0%	0%	0%
Average	**2%**	**13%**	**14%**	**11%**	**17%**	**0%**	**0%**	**8%**

Source: DNV KEMA analysis

Savings Results

Taking into account both EEMs, the Fort Bragg project resulted in 43,035 kWh in annual gross energy savings. Peak demand savings of 9.33 kW were estimated using coincident demand factors from DEER 2011 and filtering the VFD and lighting models for the peak hours of 2 p.m. to 5 p.m. A breakdown of savings by individual measure is presented in Table 107 at the beginning of this report. The ex ante savings estimates, which were acquired from the program's monthly status reports, are also provided as a point of reference.

Measure 1 – Install VFD on wastewater pump

On-site verification activities confirmed that both pumps were installed exactly as detailed in the ex ante savings calculations. The evaluation team deployed metering equipment to determine the part-load operating profile of the new system. The spot measured data showed that the pump kW at lower speeds was much less than anticipated in the ex ante savings calculations.

Measure 2 – Retrofit Light Fixtures

On-site verification activities confirmed that the majority of the lighting measure was installed as detailed in the program documentation. The evaluation team verified the fixtures installed and noted any differences between the installed fixtures and program documents. Metered data from the wastewater treatment high bay fixtures showed annual hours of operation below the

anticipated values, and the site inspection revealed that the fixtures were not equipped with occupancy sensors.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline since by definition baselines 1 and 2 are identical for this project. The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the EEM implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 110 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 110: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand Savings (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	43,035	9.33	N/A
2	2012	43,035	9.33	N/A
3	2013	43,035	9.33	N/A
4	2014	43,035	9.33	N/A
5	2015	43,035	9.33	N/A
6	2016	43,035	9.33	N/A
7	2017	43,035	9.33	N/A
8	2018	43,035	9.33	N/A
9	2019	43,035	9.33	N/A
10	2020	43,035	9.33	N/A
11	2021	43,035	9.33	N/A
12	2022	43,035	9.33	N/A
13	2023	43,035	9.33	N/A
14	2024	43,035	9.33	N/A
15	2025	43,035	9.33	N/A
Total		645,525		N/A

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Millbrae, City of (CBG-09-094)

Site Summary

This streetlight project consisted of replacing 278 HPS street light fixtures ranging from 85 to 237 watts with 278 LED street light fixtures ranging from 37 to 106 watts. Annual operating hours for all fixtures (photocell controlled) were assumed to be 4,380. Installation verification was performed by visually verifying 121 out of the 278 fixtures during the site visit. Of the 121 verified LED fixtures, all fixtures were found to have been retrofitted with the proper wattages. Both the listed wattage and actual fixture wattage were provided by the city contact. The number of fixtures retrofitted also matched the purchasing invoice provided by the city contact. No modifications of the city's tracking quantities or fixture wattages were made based on the verification sample. The main difference the ex post savings is greater than the ex ante savings is because the ex ante analysis assumed 4,100 annual operating hours (~11 hours per day), while the ex post analysis used 4,380 annual operating hours (12 hours per day). The annual operating hours should be 4,380 based on average sunrise and sunset times for Millbrae, CA.

Table 111: Savings and Realization Rate

Ex Ante Savings	Ex Post Savings	Realization Rate
64,957 kWh	74,390 kWh	114.5%

Source: DNV KEMA analysis

Table 112: City Tracking Spreadsheet Retrofit Claims

Pre-Existing Fixtures			Installed Fixtures			
Type	Nominal Wattage	Functional Wattage	Type	Nominal Wattage	Functional Wattage	Fixture Count
HPS	70	85	LED	20	37	96
HPS	70	85	LED	30	54	38
HPS	100	120	LED	20	37	5
HPS	100	120	LED	30	54	1
HPS	150	176	LED	5	90	3
HPS	70	100	LED	20	37	2
HPS	70	100	LED	30	54	25
HPS	100	138	LED	20	37	1
HPS	100	138	LED	30	54	105
HPS	200	237	LED	60	106	2

Source: DNV KEMA analysis

Table 113: Verified Sample Findings

Pre-Existing Fixtures		Installed Fixtures				
Type	Nominal Wattage	Type	Nominal Wattage	Verified Fixture Count	% of Verification Sample Properly Installed	Average Functional Wattage of Fixtures with Discrepancies
HPS	70	LED	20	96	100%	-
HPS	100	LED	30	25	100%	-
Total					100%	

Source: DNV KEMA analysis

Table 114: Verification Revised Fixture Table

Pre-Existing Fixtures			Installed Fixtures					
Type	Nominal Wattage	Functional Wattage	Type	Nominal Wattage	Revised Functional Wattage Based on Verification	Fixture Count	Verified Demand Reduction (kW)	Verified Energy Savings (kWh)
HPS	70	85	LED	20	37	96	4.61	20,182
HPS	70	85	LED	30	54	38	1.18	5,160
HPS	100	120	LED	20	37	5	0.42	1,818
HPS	100	120	LED	30	54	1	0.07	289
HPS	150	176	LED	5	90	3	0.26	1,130
HPS	70	100	LED	20	37	2	0.13	552
HPS	70	100	LED	30	54	25	1.15	5,037
HPS	100	138	LED	20	37	1	0.10	442
HPS	100	138	LED	30	54	105	8.82	38,632
HPS	200	237	LED	60	106	2	0.26	1,148
Total							17	74,390

Source: DNV KEMA analysis

Verification Sample Area Map

The area with the newly installed fixtures is too large to show, so here are three snapshots of retrofitted areas.

Figure 47: Verification Sample Area Map

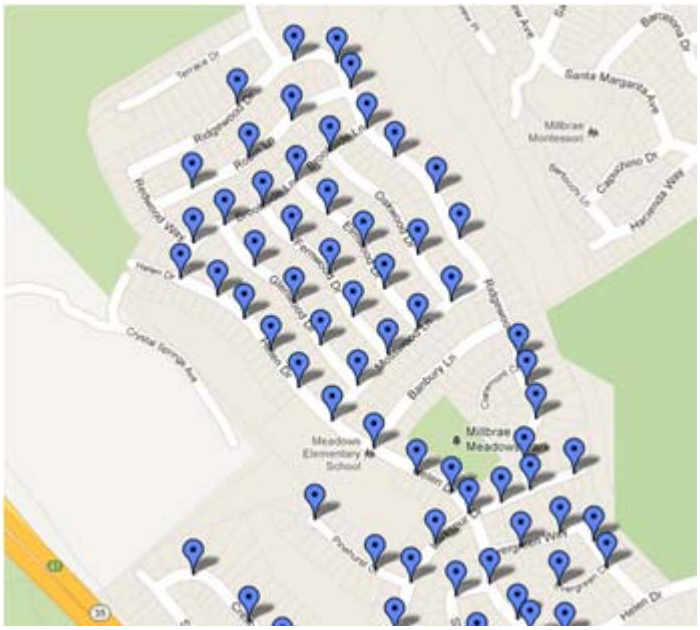


Photo Credit: DNV KEMA

Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EULof the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This

baseline considers either minimally code compliant conditions or standard practice when no code is applicable. According to the decision maker survey completed with the site contact , the pre-existing streetlighting was installed seven years ago with a EUL of 15 years.

The tables below provide life-cycle savings for the project relative to Baseline 1 on a year-by-year basis through the EUL of the longest lived measure. Under this baseline, energy savings were presumed to occur relative to the pre-existing equipment for the duration of each measure's life. For this project, the life-cycle savings estimates relative to Baseline 2 (dual baseline) are the same as the life-cycle savings relative to Baseline 1.

Table 115: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (therms/yr)
1	2011	74,390	16.98	0
2	2012	74,390	16.98	0
3	2013	74,390	16.98	0
4	2014	74,390	16.98	0
5	2015	74,390	16.98	0
6	2016	74,390	16.98	0
7	2017	74,390	16.98	0
8	2018	74,390	16.98	0
9	2019	74,390	16.98	0
10	2020	74,390	16.98	0
11	2021	74,390	16.98	0
12	2022	74,390	16.98	0
13	2023	74,390	16.98	0
14	2024	74,390	16.98	0
15	2025	74,390	16.98	0
16	2026	0	0	0
	Total	1,115,850 kWh	255 kW-years	0 therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Shasta Lake, City of (CBG-09-099)

Site Summary

The City of Shasta Lake received funds through the EECBG direct equipment purchase program to install four VFDs at two pump lift stations. The pre-existing system was already equipped with VFDs and the installation of the new VFDs did not result in any changes to the control algorithms. Generally, this would constitute a maintenance type project and would not result in savings. However, after conversations with the Energy Commission, it was determined the old VFDs were eddy-current drives and the new VFDs are electronic-pulse-width-modulated drives which are slightly more efficient.

Table 116: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 – VFDs on 75 HP Pumps	8,584	0	0	9,338	2.6	0	109%	N/A
EEM1 – VFDs on 200 HP Pumps	22,398	0	0	24,902	6.8	0	111%	N/A
Total	30,982	0	0	34,240	9.4	0	111%	N/A

Source: DNV KEMA analysis

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses *minimally code-compliant* conditions or *standard practice* as the baseline once the RUL of the pre-existing equipment is exceeded.

The overall results from Table 116 yield a life-cycle energy savings of 513,594 kWh and life-cycle demand savings of 141 kW-years for both Baseline 1 and Baseline 2 conditions, as shown in Table 117.

Table 117: Ex Post Life-cycle Savings Totals

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1	513,600	141	0
Baseline 2	513,600	141	0

Source: DNV KEMA analysis

Project Description

This project was to replace VFDs controlling two 75 HP pumps at Lift Station #3 and two 200 HP pumps at the Relief Lift Station. The pumps are used to move the main sewage to a treatment facility. In the pre-existing case, all pumps are controlled by an older model VFD. At each pump station, one pump functions as the main while the second is used as a backup. Only one pump is on at a time for each lift station. The site contact reports that due to the age of the VFDs, replacement parts may no longer be available if the VFDs failed. Although the VFDs had not yet completely failed, preemptive steps were taken to replace the VFDs to avoid future problems. EECBG funds were used to help shoulder the cost of replacing all four VFDs controlling these pumps.

Ex Ante Savings

According to the energy savings calculations provided by the Energy Commission, energy savings were calculated using the following equation:

$$Energy\ Savings = \frac{HP \times 0.746 \times 0.85}{\eta} \times 3650 \times F_1 \times F_2$$

Where,

Energy Savings is the annual energy savings in kWh,
HP is the pump horsepower rating in horsepower,
0.746 is the horsepower to kW conversion factor,
0.85 is presumably the motor loading factor,
η is motor efficiency,
3650 is the estimated total annual hours of operation,
F_1 is an assumed savings factor estimated at 30 percent, and
F_2 is an unknown factor estimated at 15 percent.

The algorithm is non-standard and is likely an approximation for the new VFDs. It is not stated what assumptions are used to determine these values and what the baseline conditions and postretrofit conditions are. But from the structure of the algorithm, it is comparing the VFDs to a constant speed with bypass valve control scheme.

Project Evaluation

A site visit was planned with the understanding that the pre-existing conditions had no VFDs. However, after talking with the site contact, who had intimate knowledge of how the pumps operated before and after the VFD replacement, it was assumed that there were no energy savings associated with this project and so a site visit would yield no useful data. However, after further conversations with the Energy Commission, it was determined that the new VFD technology was likely to produce savings. While a site visit was not possible, a DNV KEMA engineer used a spreadsheet based analysis method to estimate savings.

According to the site contact, there are four pumps (two 75 horsepower pumps at the Lift Station #3 and two 200 horsepower pumps at the Relief Lift Station) on variable speed drive control. Pump speed control are based off of sonar signals which detect liquid level of the sewage at the intake. The pumps are on one at a time for each lift station. The site contact also stated that the old VFDs were still working at the time of the replacement.

Due to the age of the old VFDs there was growing concern that replacement parts may no longer be available in the future if certain VFD components needed replacing. City policy was to replace failing parts with like parts and if the EECBG funds were not available, the city would have replaced the VFDs with another similar VFD regardless.

Power consumption of the drive was modeled as a function of drive efficiency, loading, and motor efficiency. The motor efficiency and loading were constant across the pre and postretrofit cases, but the drive efficiency was a function of drive speed and varied between the two cases. Drive efficiency was calculated using data from a Tip Sheet[28] from the DOE.

Conversations with the site contact revealed that the VFDs operate between speeds of 52 Hz and 60 Hz. Motor efficiency was assumed to be 0.93, as provided by the ex ante calculations.

Savings for the measure were determined to be the difference between the consumption of the eddy-current drives and the consumption of the electronic-pulse-width-modulated drives.

It should be noted that while there are 4 VFDs, two of the pumps operate as backup only, so there are only two motors pumping at any given time. Because of this, savings were calculated as if there were only two VFDs retrofitted.

Discussion

Ex post energy savings for the VFD pumps were 111 percent of ex ante estimates. This discrepancy is largely due to an overly simplistic ex ante calculation. The ex ante algorithm was not standard and does not state what assumptions were used to determine the input values.

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28 U.S. Department of Energy. *Is it Cost Effective to Replace Old Eddy-Current Drives?* http://www1.eere.energy.gov/manufacturing/tech_deployment/pdfs/motor_tip_sheet12.pdf.

Ex Post Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

Because there is no code that requires VFDs on pumps, Baseline 1 and Baseline 2 are equal for these measures. EUL values were sourced from the 2011 DEER database. The measures were assigned an RUL of one year since the original VFDs were past their useful life but still functional.

Table 118: Values Used in Ex Post Life-cycle Savings Calculations

Measure	Early Replacement			Expected Replacement			EUL (years)	RUL (years)
	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)		
EEM1 – VFDs on 75 HP Pumps	9,338	2.6	0	9,338	2.6	0	15	1
EEM1 – VFDs on 200 HP Pumps	24,902	6.8	0	24,902	6.8	0	15	1
Total	34,240	9.4	0	34,240	9.4	0		

Source: DNV KEMA analysis

Table 119: Baseline 1 and 2 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (therms/yr)
1	2012	34,240	9.4	0
2	2013	34,240	9.4	0
3	2014	34,240	9.4	0
4	2015	34,240	9.4	0
5	2016	34,240	9.4	0
6	2017	34,240	9.4	0

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (therms/yr)
7	2018	34,240	9.4	0
8	2019	34,240	9.4	0
9	2020	34,240	9.4	0
10	2021	34,240	9.4	0
11	2022	34,240	9.4	0
12	2023	34,240	9.4	0
13	2024	34,240	9.4	0
14	2025	34,240	9.4	0
15	2026	34,240	9.4	0
Life-cycle Total		513,600	141	0

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Tuolumne, County of (CBG-09-106-A)

Site Summary

Tuolumne County implemented a lighting retrofit project that was evaluated as described in this report. This project involved the relamping or replacement of 1,885 fixtures throughout 10 Tuolumne county buildings and the installation of three programmable thermostats. The following areas were included in the retrofit: administration building, probation building, senior center, jail, sheriff building and trailer, ANF parking garage, main library, adult day health care building, and the health and wellness center. Typical operating hours for the administration building, probation center, senior center, and health and wellness center are 7 a.m. to 5 p.m. Monday through Friday. The main library normally operates from 10 a.m. to 6 p.m. Tuesday through Saturday, and the county jail ANF parking garage and sheriff buildings operate 24 hours per day.

According to the Energy Commission, Tuolumne County completed the lighting project under budget and was able to implement a second HVAC project at the County Library. This HVAC project was not sampled, but the results are included in the evaluation of the EECBG. The ex ante savings for the HVAC project are 5461 kWh and 40 therms.

The implemented measures at Tuolumne County buildings included (EEM1) retrofit lighting fixtures and (EEM2) install three programmable thermostats. Table 120 summarizes the ex post and ex ante savings estimates for each measure.

Table 120: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1– Retrofit light fixtures	290,658	73	0.0	288,749	62.8	0.0	99%	N/A
EEM2 –Install programmable thermostats	5,461	0.0	40	5,461	0.0	40	100%	100%
Total	296,119	73	40	294,210	62.8	40	99%	100%

Source: DNV KEMA analysis

There is very little difference between the ex post savings and those estimated in the ex ante calculations. Due to the large number of fixtures, building types, and space types, the evaluation team could not gather statistically significant metered lighting data within the

project budget. As such, the evaluation team inspected a large portion of the light fixtures installed as part of this project and verified the hours of operation with site personnel.

Savings for EEM1 were reduced slightly after the fixtures in the parking garage were found to be vapor tight standard ballast factor 28W T8 fixtures rather than the low ballast factor 28W T8 fixtures listed in the lighting survey.

Savings for EEM2 remain the same. The evaluation team confirmed the installation of all thermostats and that they were correctly programmed.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For the lighting fixture retrofit and thermostat replacement, the two baselines are identical.

For lighting retrofits (EEM1), DEER provides an EUL of 15 years. For programmable thermostats (EEM2), DEER provides an EUL of 11 years.

Table 121: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction (kW)	Natural Gas Energy Savings(Therms)
Baseline 1&2	4,385,845	62.8	0.0

Source: DNV KEMA analysis

Project Description

This project involved the installation of three programmable thermostats and the relamping or replacement of 1,885 fixtures throughout 10 Tuolumne county buildings. The following areas were included in the retrofit: administration building, probation building, senior center, jail, sheriff building and trailer, ANF parking garage, main library, adult day health care building, and the health and wellness center.

Measure 1 – Retrofit Light Fixtures

EEM1 consisted of a complete lighting retrofit for all 10 buildings involved in the project. A room-by-room lighting survey was completed, which documented baseline as well as replacement fixture types for all 1,885 fixtures replaced as part of this project. The vast majority of the line items involve the relamping of standard ballast factor 32W T8 fixtures with 28WT8

fixtures and low ballast factor high efficiency ballasts. Additional measures included replacing 68 incandescent exit signs with new LED fixtures and 133 incandescent fixtures with compact fluorescent screw-in units. The remaining fixtures are a mix of 2-feet, high-performance T8 units and outdoor wallpack fixtures.

Savings were calculated line-by-line using the following algorithm:

$$\textit{Annual savings (kWh)} = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Pre-retrofit annual hours of operation for usage group
PostRunHrs	= Postretrofit annual hours of operation for usage group (assumed to be the same as no measures involved the installation of occupancy sensors)

HVAC interactive effects were not accounted for in the ex ante savings estimates, and are also not included in the ex post analysis.

Measure 2-Install Programmable Thermostats

EEM2 consisted of installing three new programmable thermostats in the adult day healthcare and the health and wellness center. Savings were calculated using a simple bin analysis, where the total occupied hours for heating and cooling were reduced by 337 hours per year. The analysis estimated a total savings of less than 2 percent of the baseline cooling load.

Project Evaluation

An ERS engineer visited the facility on February 8, 2012, to verify the installation of each measure, verify the hours of operation with site staff, and verify that equipment specifications met those listed in the program documentation.

Measure 1 –Retrofit Light Fixtures

On-site verification activities confirmed that the lighting measure was installed as detailed in the program documentation. A full lighting survey was included with the application, which listed room-by-room baseline and postinstallation fixture quantities and fixture types. ERS verified the installation of 499 fixtures in 108 of the 767 rooms listed in the lighting survey. These rooms represented 26 percent of the total number of fixtures and 34 percent of the total measure savings.

For each fixture type the evaluation team verified that the lamps and ballasts installed matched those listed in the lighting survey. The evaluation team found one small discrepancy and one

larger discrepancy that affected the total project savings. The findings are listed below in Figure 48.

Figure 48: Lighting Survey Adjustments

ID	Line Item	Space Name	kW Savings Change	kWh Savings Change	Description
1	789	Probation – copy area	0	210	2-lamp fixtures, not 4-lamp fixtures
2	465,466,469,470	ANF parking garage	-1.20	-10,547	Listed as low power ballast, but installed high power ballast
Total			**-1.16**	**-10,337**	

Source: DNV KEMA analysis

The fixtures in the parking garage were incorrectly listed as low ballast factor units when normal ballast factor fixtures were installed. This increases the postinstallation wattage of each of the fixtures from 84 to 95 W. This adjustment led to an annual decrease in savings of 10,547 kWh. The photos in Figure 49 and Figure 50 below show the light fixtures and ballasts adjusted as part of the inspection process.

Figure 49: Parking Garage Vapor Tight Fixtures

Photo Credit: DNV KEMA

Figure 50: Parking Garage Fixture Ballast

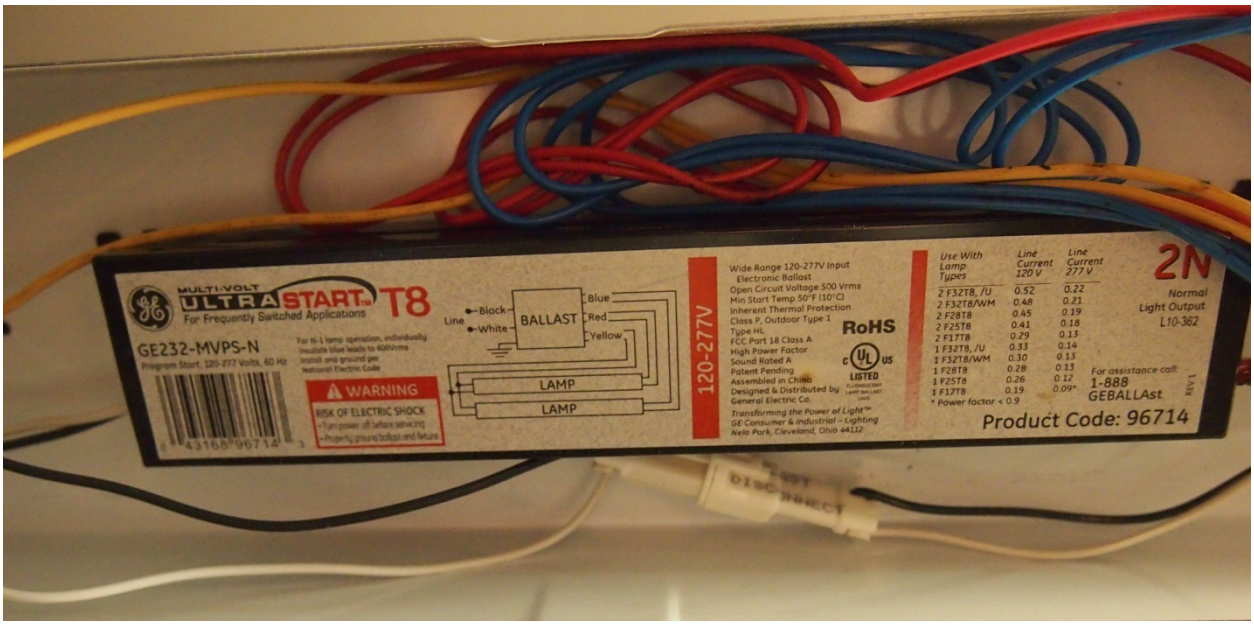


Photo Credit: DNV KEMA

Measure 2 –Install Programmable Thermostats

The evaluation team confirmed the installation and programming of all thermostats listed in the program documentation. The annual hours of operation and occupied and unoccupied hours of operation used in the original analysis were confirmed as consistent with the space types and standard building usage patterns.

Savings Results

Taking into account both EEMs, the Tuolumne County project resulted in 294,210 kWh in annual gross energy savings. A breakdown of savings by individual measure is presented at the beginning of this report. The ex ante savings estimates, which were acquired from the program's monthly status reports, are also provided as a point of reference.

Discussion

Measure 1 –- Retrofit Light Fixtures

On-site verification activities confirmed that the lighting measure was installed as detailed in the program documentation. The evaluation team verified the installation of 499 fixtures in 108 of the 767 rooms listed in the lighting survey. These rooms represented 26 percent of the total number of fixtures and 34 percent of the total measure savings. Only one set of fixtures did not match those listed in the program documentation and resulted in a 4 percent reduction in total measure savings.

Measure 2 –Install Programmable Thermostats

As discussed previously, the evaluation team verified all equipment and analysis assumptions submitted in the original application. No changes were made to the calculation algorithm. The savings from EEM2 represent less than 2 percent of the total project savings.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline. The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the EEM implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 122 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 122: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	294,210	62.8	0.0
2	2012	294,210	62.8	0.0
3	2013	294,210	62.8	0.0
4	2014	294,210	62.8	0.0
5	2015	294,210	62.8	0.0
6	2016	294,210	62.8	0.0
7	2017	294,210	62.8	0.0
8	2018	294,210	62.8	0.0
9	2019	294,210	62.8	0.0
10	2020	294,210	62.8	0.0
11	2021	288,749	62.8	0.0
12	2022	288,749	62.8	0.0
13	2023	288,749	62.8	0.0
14	2024	288,749	62.8	0.0
15	2025	288,749	62.8	0.0
Total		4,385,845kWh		0.0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT EECBG

Stanislaus, County of (CBG-09-111)

Site Summary

This project involved replacing 344 HPS streetlight fixtures with induction fixtures throughout the city. The 344 fixtures were purchased using funding from the EECBG. Table 123 summarizes the ex post and ex ante savings estimates for this project.

Table 123: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand Reduction (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand Reduction (kW)	Gas Energy (Therms)	Electric	Gas
Induction Streetlighting	128,856	N/A	N/A	164,241	N/A	N/A	127.5%	N/A
Total	128,856	0.0	0.0	164,241	0.0	0.0	127.5%	N/A

Source: DNV KEMA analysis

Ex post savings are based on the size of the lamp replaced (100 - 250 W, according to the site contact) and the size of lamp installed (85-150 W). Ex ante savings analysis was not provided, but it is presented as being based on a variety of possible lamps sizes being replaced (70–400 W replaced by 50–150 W lamps). The ex ante values are based on the tracking savings from September 17, 2012.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For streetlighting fixture retrofits, the two baselines are identical. Industrial standard for streetlights have an EUL of 15 years. The life-cycle savings summary can be found in Table 124.

Table 124: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1&2	2,463,615	0.0	0.0

Source: DNV KEMA analysis

Project Description

This project involved the replacement of 344 streetlight fixtures throughout the city of Modesto. HPS fixtures were replaced with induction fixtures using the existing poles.

Savings were calculated using the following algorithm:

$$Annual\ savings\ (kWh) = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= *Baseline fixture quantity (#)*
RFW	= *Retrofit fixture wattage (kW)*
RFQ	= *Retrofit fixture quantity (#)*
BaseRunHrs	= *Preretrofit annual hours of operation for usage group, 4,380 hours/year for ex post analysis*
PostRunHrs	= *Postretrofit annual hours of operation for usage group (assumed to be the same, as no changes were made to the lighting controls)*

Project Evaluation

The evaluation team visited the city on May 16, 2012, to verify the installation of each measure and the hours of operation and to ensure that the equipment specifications met those listed in the program documentation. The evaluation team verified a sample of twenty fixtures that had been replaced, and they confirmed through interviews with city staff that the baseline fixture wattage matched the project documentation.

The savings analysis input values and annual energy savings results by fixture group are shown below in Table 125.

Table 125: Ex Post Savings Analysis

Preretrofit					Postretrofit				Savings
Fixture Descrip-tion	Qty	Fixture Wattage (W)	Annual Operating Hours	Annual Energy (kWh/yr)	Fixture Descrip-tion	Fixture Wattage (W)	Annual Operating Hours	Annual Energy (kWh /yr)	Annual Energy Savings (kWh /yr)
250 W HPS	27	295	4,380	34,886	150 W Induction	150	4,380	17,739	17,147
200 W HPS	111	250	4,380	121,545	135 W Induction	135	4,380	65,634	55,911
150 W HPS	198	188	4,380	163,041	85 W Induction	85	4,380	73,716	89,326
100 W HPS	8	138	4,380	4,836	85 W Induction	85	4,380	2,978	1,857
Total	344			324,308				160,067	164,241

Source: DNV KEMA analysis

Savings Results

The ex post savings calculation resulted in 164,241 kWh in annual energy savings, which represents a 127.5 percent realization rate compared to the ex ante estimates.

Discussion

On-site verification activities confirmed that the lighting measure was installed as detailed in the program documentation. A spreadsheet locating the replaced streetlights was provided by the site contact. This spreadsheet was used to make visual confirmation that a sample of twenty lights had been installed. The Energy Commission provided a revised spreadsheet from the site contact following the site visit, with slightly revised quantity of fixtures. The evaluation team made several attempts to verify these changes to the retrofit quantities and wattage with the on-site contact, but the site contact did not respond these verification requests. Increased uncertainty is introduced into the analysis and saving determination by accepting these changes in the project without documentation to verify the purchase and installation of these fixtures.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1). The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the EEM implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 126 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 126: Life-cycle Savings

Life-cycle Year	Calendar Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW-years)	Natural Gas Energy Savings (Therms/yr)
1	2012	164,241	N/A	N/A
2	2013	164,241	N/A	N/A
3	2014	164,241	N/A	N/A
4	2015	164,241	N/A	N/A
5	2016	164,241	N/A	N/A
6	2017	164,241	N/A	N/A
7	2018	164,241	N/A	N/A
8	2019	164,241	N/A	N/A
9	2020	164,241	N/A	N/A
10	2021	164,241	N/A	N/A
11	2022	164,241	N/A	N/A
12	2023	164,241	N/A	N/A
13	2024	164,241	N/A	N/A
14	2025	164,241	N/A	N/A
15	2026	164,241	N/A	N/A
Life-cycle Total		2,463,615 kWh	0 kW-years	0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Marin, County of(CBG-09-126)

Site Summary

Marin County was awarded funds for a variety of EEMs that were implemented throughout the Civic Center building in San Rafael, at parking lots and pathways, and at Gnoss Airport. In all, the measures encompassed insulation upgrades, a DHW retrofit, ozone laundry, exterior lighting upgrades to LED and LED streetlights. While the LED streetlight measure was implemented, it was not evaluated and the savings of 235,910 kWh are not presented in this report.

Ex post energy savings were estimated at 118,516 kWh and 24,490 therms for this project. This represents 38 percent and 55 percent of the ex ante estimates for electricity and natural gas savings (Table 127), respectively. The lower energy savings calculated here is primarily the result of the wall and roof insulation measures. While both wall and roof insulation were found during the site visit inspection, the energy model used to determine energy savings were found to be critically flawed. Although the wall and roof insulation were indeed modeled, there were also arbitrary revisions made to the model of the HVAC system at the discretion of the ex ante modeler which were unrelated to the two measures and did not occur. As a result, the ex ante energy savings estimates are overstated because they also include savings from these arbitrary changes and are not representative of the insulation measure on its own.

In contrast, energy savings for the remaining measures were similar to the ex ante claims and were found to be installed as described with only minor differences found during the site visit inspection. Detailed discussion by measure is provided towards the end of this report.

Table 127: Energy Savings Summary

Measure	Ex Ante[29]			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1-DHW retrofit	0	Not reported	16,541	0	0.0	16,547	N/A	100%
EEM2-LED lights, Civic Center	54,365	Not reported	0	50,554	0.0	0	93%	N/A

29 Ex ante values come from the information in the tracking database provided to KEMA by the Energy Commission.

Measure	Ex Ante[29]			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM3-LED lights, Gnoss Airport	20,674	Not reported	0	20,827	0.0	0	101%	N/A
EEM4-Ozone laundry	0	Not reported	7,148	0	0.0	6,469	N/A	91%
EEM5-Wall insulation	60,872	Not reported	7,182	11,722	Not reported	1,673	19%	23%
EEM6-Roof insulation	175,744	Not reported	13,852	35,413[30]	Not reported	-199	20%	-1%
Total	311,655	0.00	44,723	118,516	0.0	24,490	38%	55%

Source: DNV KEMA analysis

The overall results from Table 127 yield a life-cycle energy savings of 1,777,738 kWh and 335,010 therms (Table 128). Life-cycle savings were calculated relative to the pre-existing condition for the full EUL of the equipment.

Table 128: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Existing Baseline	2,013,415	0	342,375

Source: DNV KEMA analysis

Project Description

In total, there are six EEMs for this project. The measures are the following:

- The existing DHW boiler at the Civic Center was 80 percent efficient and was replaced with a 98 percent efficient boiler.
- HID mushroom head lighting fixtures rated at 90 Watts per fixture were replaced with LED fixtures rated at 32 Watts per fixture. These were implemented at Civic Center pathways and parking lots.
- HID fixtures at Gnoss Airports ranging from 213 to 465 Watts per fixture were replaced with LED fixtures rated at 95 to 144 Watts per fixture.
- Equipment installed at a laundry facility which serves the jail allowed for the use of ozone in the laundering process.

30 Both electric and gas energy savings include interactive effects from wall insulation shown above. Interactive effects, however, were not significant (<2 percent).

- R-4.5 rigid insulation was added to the Civic Center at the side of the atrium walls to improve the wall insulation value.
- Spray on roof insulation rated at R-12 was added to the existing Civic Center roof improving the roof insulation value.

Ex Ante Savings

EEM1: DHW retrofit – Energy savings were calculated by first estimating the building's total water supply fixture units based off of an estimate of all hot water fixtures. This value was converted to a hot water flow rate using a standard demand curve from the California Plumbing Code and assuming that 75 percent of the water supply is hot water. Next, the following equation was used to determine and compare the energy consumption using an 80 percent efficient boiler versus a 98 percent efficient boiler:

$$Therms = \left(\frac{GPM \times \Delta T \times 500 \times 4{,}368}{\eta \times 100{,}000}\right)$$

Where *GPM* is the estimated hot water supply flow rate (60 GPM), *ΔT* is the temperature rise of the DHW (55°F), *500* is a conversion factor to Btu/h, *4,368* is the number hours in operation per year, *η* is the boiler efficiency (80 percent or 98 percent), and *100,000* is the Btu/h to therms conversion factor. The result was compared to billing data which shows a reasonable match.

EEM2 & EEM3: LED lights – Energy savings are calculated using standard equations which takes into account pre and postretrofit fixture wattages, quantities and hours of operation. The fixtures are estimated to operate for 12 hours a day. The equation is the following:

$$Savings = (kW_{Pre} - kW_{Post}) \times N \times Hours$$

Where *Savings* is the energy savings per fixture, *kW* is the pre and postretrofit fixture wattages, *N* is the quantity, and *Hours* is the annual hours of operation

EEM4: Ozone laundry – For this measure, an estimate on the number of laundry loads performed per day along with industry estimates of hot water usage to complete each load were estimated for the baseline and ozone laundry cases. An annual hot water usage in gallons was determined based on this information. This value was then converted to an annual energy consumption by assuming the boiler used to generate the hot water was 80 percent efficient and the hot water was raised to 140°F. The general approach and assumptions are in line with industry values.

For this measure additional gas savings were attributed to the dryer. The rationale is that ozone laundry leaves the clothes dryer and will require less drying time. The ex ante analysis shows that the reduction in dryer usage is 40 percent.

EEM5 & EEM6: Wall and Roof insulation. – The implementer first built a calibrated model to represent the existing building, its HVAC systems, and typical operation. The model was calibrated to 1 percent to 5 percent of the building's 5 year average electric and gas energy usage, respectively.

To estimate energy savings for the wall and roof insulation, DNV KEMA assumed that only the insulation R-value for the wall and roof were altered in the calibrated model. The report does not describe how the ex ante energy savings estimates were actually computed but this is the standard approach for insulation measures. A close review of the input files show that the wall and roof insulation were indeed upgraded but additional changes to each HVAC system were also made. The changes were significant and included reductions in the airflow rates, cooling capacities, and heating capacities. Savings for each measure was done separately in two postretrofit models and were compared to the calibrated base case model. The measures, however, were not simultaneously included to examine interactive effects. Changes to the HVAC system in the two postretrofit models were altered at the discretion of the modeler and were not the same for wall and roof insulation cases. It is not described in the project files as to how these values were estimated.

It should be noted that the majority of the savings do not come from the insulation but actually arises from the modeler's arbitrary changes to the HVAC system.

Project Evaluation

A DNV KEMA field engineer visited the project's sites on March 12th, 2012 to verify measure installation. No metering was performed for this site because either the measures generated gas savings which are not typically metered or the electric savings by measure cannot be isolated from the entire site energy use. For the DHW measure, equipment nameplate data was obtained and a flue gas analysis was performed to verify the new unit's thermal efficiency.

For the lighting measures, DNV KEMA obtained documents of the lighting retrofit which showed fixture locations, pre and post fixture wattages, and quantities. These documents were used to reference each fixture during the site visit.

Only visual verification was performed for the ozone laundry and insulation measures. Additionally, the DNV KEMA engineer inquired about the laundry usage patterns and visited the central plant to verify the major HVAC parameters used in the Energy Pro model which matched.

EEM1: DHW retrofit – The boiler nameplate showed a new 98 percent efficient boiler was installed with an input capacity of 600 kBtu/h. The flue gas analysis was in line with the rated boiler efficiency and registered between 94-98 percent efficiency during the flue gas analysis test. The site contact indicated that typical building hours of operation were from Monday through Friday from 7 a.m. to 6 p.m. although weekend operation for some of the spaces were not uncommon. Based on these responses and the result of the flue gas analysis test, DNV KEMA finds that the assumptions used in energy savings estimates are reasonable and no change to the calculations are made. This measure saved 16,547 therms and represents 100 percent of the ex ante estimates.

EEM2: LED lights, Civic Center – The original project files shows that 214 mushroom fixtures were upgraded to LED. However, DNV KEMA found only 199 fixtures were upgraded. The remaining fixtures were not changed either due to the absence of the fixture poles (1 total) or

were to be included in a future retrofit that is not part of the scope for this grant (14 total). The site contact indicated that all exterior lighting fixtures are on photocell controls.

A revision to the total quantity of fixtures resulted in lower energy savings. This is estimated at 50,554 kWh and uses a similar equation as the ex ante calculations.

EEM3: LED lights, Gnoss Airport – The original project files shows that a total of 29 HID fixtures rated at 213 Watts per fixture and 4 HID fixtures rated at 400 Watts per fixture were retrofitted with 95 Watt and 144 Watt LED fixtures, respectively. However, the postretrofit quantities found during the site visit were different. In all, 32 LED fixtures rated at 95 Watts, and 3 fixtures rated at 144 Watts were found. Similar to EEM2, all fixtures are on photocell controls and only operate during the evening times. Due to the higher number of retrofitted fixtures, the energy savings were found to be slightly higher than the ex ante savings claim. Energy savings for this measure is estimated at 20,827 kWh. A comparison of the fixtures found during the site visit with those claimed in the project files is shown in Table 129 below.

Table 129: Quantity of Fixtures Found During Site Visit Compared with Fixture Quantity Claims

Fixture Location/description	Quantity Claimed	Quantity Found
Civic Center Parking Lots & Pathways, Mushroom head, 32 Watt LED light	214	199
Gnoss Airport, 95 Watt LED	29	32
Gnoss Airport, 144 Watt LED	4	3

Source: DNV KEMA analysis

EEM4: Ozone laundry – Ozone equipment was found installed at the laundry facility of the jail. The ozone equipment served four washers, three rated at 95 pounds per load capacity and one at 27 pounds per load capacity. A number of gas dryers were found at the laundry facility but the input capacity could not be determined since the nameplate could not be accessed. Facility staff was questioned as to how many loads were performed during a typical day and whether there were any differences in the dryer usage before and after the ozone laundry installation. The laundry load estimates were in line with the assumptions used in the ex ante calculations and therefore no changes were made to the energy savings estimates for the washer portion.

However, the staff indicated that prior to the installation of the ozone, the dryers typically ran for 45 minutes for each cycle and the staff did not notice any changes to the dryer after the ozone was installed.

A check on the current dryer setting show a run time of 40 minutes or 89 percent of the original runtime. In comparison, the ex ante algorithm assumes a run time reduction to 60 percent of the original runtime. The runtime values were revised to actual site conditions and resulted in a lower energy savings relative to ex ante estimates. Energy savings for this measure is calculated at 6,469 therms using the following equation:

$$Savings = \frac{Loads \times\ 0.75\ \times 350{,}000}{100{,}000} \times SF$$

Where *Savings* is the energy savings in therms, *Loads* is the typical number of loads performed each day (15), *0.75* is the dryer runtime in hours, *350,000* is the rated dryer input capacity for similar 95 lb dryers, *100,000* is a Btu/h to therms conversion factor, and *SF* is the savings factor (40/45 = 0.89).

EEM5: Wall Insulation – The square footage of the atrium walls where new R-4.5 rigid insulation panels were installed was measured with a walking wheel. The overall square footage value of 19,920 square feet was within 10 percent of the modeled value (22,292 square feet). Given the accuracy of the walking wheel, the measurement confirms the total modeled wall area is reasonable so no changes to the building shell were made. DNV KEMA found that no changes were made to the airflow rates, heating coils, or cooling coils which would change the capacity of the HVAC systems.

To create the postretrofit "wall insulation" model, DNV KEMA took the original calibrated model and changed the wall insulation value from R-0 to R-4.5. Note that this was the only change that was made. The results of the "wall insulation" model were compared to the calibrated baseline model to establish the energy savings for this measure. Energy savings is estimated at 11,722 kWh and 1,673 therms.

EEM6: Roof Insulation – The DNV KEMA engineer accessed the roof area and found spray on insulation matching the description found in the project files. In addition, the building plans were examined and showed a total roof area of 76,000 square feet if viewed as a flat area. Considering the slope of the roof, this translates to a potential 76,000 to 87,400 total square feet of roof depending on the actual tilt of the roof (from 0° to 30° slope). In the model, the roof area is estimated at 85,577 square feet and is considered reasonable based on the site findings. The roof is indeed sloped but the degree of slope was not measured and can only be visually estimated at less than 30°.

To create the postretrofit "roof insulation" model, DNV KEMA took the "wall insulation" model from EEM5 and altered the roof insulation to have R-12 spray on roof insulation. This model includes <u>both</u> the postretrofit roof and wall insulation. In this way, interactive effects from both insulation measures can be evaluated. The results of this composite model were compared to the calibrated baseline model to establish the energy savings for both measures. Energy savings from the wall insulation was also subtracted in order to prevent double counting and reported separately in Table 127. Energy savings is estimated at 35,413 kWh for this measure with a 199 therms penalty. Note that similar to EEM5, no changes to the HVAC system air flow rates, cooling capacity, and heating capacity were made because no evidence were found of such changes.

Savings Results

Considering the implementation of all six EEMs, this site saved 118,516 kWh of electric energy and 24,490 therms of gas energy. Table 127 breaks down the ex post energy savings by measure. The ex ante energy savings are also provided for comparison.

Discussion

EEM1: DHW retrofit – Ex post energy savings are nearly identical to ex ante estimates since no discrepancy was found during the site visit and the assumptions used to determine energy savings were reasonable. There is a minor 6 therms difference which is likely due to an early mathematical rounding at some point in the calculations.

EEM2: LED lights, Civic Center – Ex post energy savings are 93 percent of ex ante estimates. DNV KEMA found 199 retrofitted lights versus the 214 claimed in the project files and accounts for this difference.

EEM3: LED lights, Gnoss Airport – Ex post energy savings are 101 percent of ex ante estimates and are due to more lights being retrofitted than what was claimed. A total of 35 fixtures were retrofitted versus the 33 claimed in the project files and accounts for this difference. Details by fixture types are provided in Table 129.

EEM4: Ozone laundry – Ex post energy savings are 91 percent of ex ante estimates. The discrepancy is due to assumptions used for the dryer savings. Ex ante algorithms assumed a reduction to 60 percent runtime due to the ozone laundry. As found on-site, the reduction in run time was only reduced slightly to 89 percent of the original runtime and resulted in the lower ex post savings estimates.

EEM5: Wall Insulation – While the wall insulation was indeed found installed and modeled in EnergyPro, ex post energy savings for this measure was found to be significantly lower than ex ante estimates (19 percent for electric and 23 percent for gas energy). This is due to the fact that in addition to revising the wall insulation R-value in the ex ante model, the modeler actively chose to revise key HVAC parameters instead of letting the modeling program determine this. Almost all the HVAC system had revisions to the supply fan airflow rates, system heating capacities, and system cooling capacities. This approach to modeling is not permitted unless actual changes to these systems were performed. If these changes were done, it would fall under a separate measure which would either describe fan control changes or HVAC capacity reduction which is unrelated to the insulation measure. Furthermore, none of these changes were found on-site.

The standard practice for modeling insulation measures is to only alter the insulation value in the proposed model while leaving everything else unchanged. This allows the modeling program to determine the correct HVAC loads to be performed. The purpose of using the program is to rely on established DOE-2 modeling protocols rather than guessing how the HVAC system will change. While the baseline model was well built and calibrated to excellent tolerances, the implementer's approach to determine savings for this measure using the proposed EnergyPro model is highly questionable.

EEM6: Roof Insulation – The same faults found in EEM5 are repeated here in the roof insulation measure. When the HVAC changes are removed, the energy savings come to about 20 percent of the ex ante estimates (35,413 kWh versus 175,444), along with an energy penalty for gas rather than a significant gas savings (-199 therms versus 13,852 therms). The ex ante energy

savings do not actually come from the insulation upgrade itself but are due to revisions to the HVAC capacity which are unfounded.

As mentioned above, it is standard practice to allow the DOE-2 engine in the modeling program to determine changes to the HVAC operation rather than actively revising the HVAC parameters. This is because there are many interactive inputs and the results cannot be easily predicted.

For example, when the HVAC adjustments made by the original modeler were removed, there is a gas penalty despite adding more roof insulation. This is not expected since more insulation will tend to drive down heating costs. While it is true that gas energy savings occur during periods of very cold weather, during milder weather, there is an unexpected gas energy penalty. An examination of the output files show that the gas penalty occurs at periods in the afternoon and early evening times. The cause of the gas energy penalty is due to the higher insulation value preventing the attic temperatures to build up when solar gains are most significant and when the weather is sufficiently cold to require heating (an interactive effect that cannot be easily predicted). The attic space acts as a tempering medium and prevents more significant heat loss under the baseline case but with additional insulation, this tempering medium is lost or attenuated. In this case, the energy penalty during mild weather periods cancel out any energy gains from colder periods with a net loss of 199 therms. The DOE-2 engine used in the modeling program is a much more reliable predictor of energy consumption and should be relied on for measures of this type.

Ex Post Life-cycle Savings

Typically, energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

All measures for this project used only Baseline 1 because either the measures were add-on measures and can only compared to the existing conditions or the existing efficiency was the same as expected-replacement baseline. For the exterior lighting, there are no establish expected-replacement baselines so the existing fixtures are used.

Details of this calculation are shown in Table 130.

Table 130: Values Used in Life-cycle Savings Calculations by Measure

Measure	Baseline 1		EUL (years)	RUL (years)
	Electric Energy (kWh)	Gas Energy (Therms)		
EEM1-DHW retrofit	0	16,547	15	0
EEM2-LED lights, Civic Center	50,554	0	15	N/A
EEM3-LED lights, Gnoss Airport	20,827	0	15	N/A
EEM4-Ozone laundry	0	6,469	10	N/A
EEM5-Wall insulation	11,722	1,673	20	N/A
EEM6-Roof insulation	35,413	-199	20	N/A

Source: DNV KEMA analysis

When considering Baseline 1 over the entire life of the measure, this project yields an estimated energy savings of 1,937,908 kWh (Table 131).

Table 131: Baseline 1 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	118,516	0.0	24,490
2	2012	118,516	0.0	24,490
3	2013	118,516	0.0	24,490
4	2014	118,516	0.0	24,490
5	2015	118,516	0.0	24,490
6	2016	118,516	0.0	24,490
7	2017	118,516	0.0	24,490
8	2018	118,516	0.0	24,490
9	2019	118,516	0.0	24,490
10	2020	118,516	0.0	24,490
11	2021	118,516	0.0	18,021
12	2022	118,516	0.0	18,021
13	2023	118,516	0.0	18,021
14	2024	118,516	0.0	18,021
15	2025	118,516	0.0	18,021
16	2026	47,135	0.0	1,474

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
17	2027	47,135	0.0	1,474
18	2028	47,135	0.0	1,474
19	2029	47,135	0.0	1,474
20	2030	47,135	0.0	1,474
Life-cycle	Total	2,013,415	0.0	342,375

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Alameda, County of(CBG-09-129A)

Site Summary

The County of Alameda was awarded funds to retrofit outdoor and indoor lighting fixtures at the Santa Rita Jail facilities in Dublin. The project replaced various HPS fixtures with induction type fixtures.

Ex post energy savings were estimated at 750,535 kWh and represents 106 percent of the ex ante estimates (Table 132). The slightly higher energy savings calculated here was primarily the result of 18 fixtures at the Quasi Yard Housing location which were not accounted for in the ex ante calculations.

Table 132: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
Exterior Lighting	618,619	0.0	0	635,841	0.0	0	103%	N/A
Interior Lighting	88,158	14.1	0	114,694	13.5	0	130%	N/A
Total	706,777	14.1	0	750,535	13.5	0	106%	N/A

Source: DNV KEMA analysis

The overall results from Table 132yield a life-cycle energy savings of 11,258,031 kWh (Table 133). Life-cycle savings were calculated relative to the pre-existing condition for the full EUL of the fixtures.

Table 133: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1 & 2	11,258,031	202.5	-

Source: DNV KEMA analysis

Project Description

This project was for the retrofit of exterior and interior lighting fixtures at the Santa Rita Jail facility. A total of 402 HPS fixtures were replaced with induction fixtures. The pre-existing

fixtures housed HPS bulbs ranging from 250 to 1000 Watts versus the induction fixtures which housed bulbs ranging from 120 to 540 Watts. The exterior lighting fixtures are on photocell controls while the interior fixtures at the warehouse facilities are on timer control. There is no change in lighting control strategy except at one of the warehouses which was initially on 24 hours a day. Those (24) fixtures are replaced with a manual timer and are turned on based on need after the retrofit was completed.

Ex Ante Savings

The ex ante savings used standard spreadsheet analysis. The algorithm included pre and post lighting fixture wattages, quantities, and estimates in hours of operation. The updated energy calculations provided by the County of Alameda shows an energy savings of 706,776 kWh for all fixtures on EECBG funding.

Project Evaluation

A DNV KEMA field engineer visited the project's sites on February 9th, 2012 to verify measure installation. The measures are straightforward and only verification of the quantities and hours of operation were required for this site. No monitoring was performed for this site because it is not possible to isolate the power consumption of the affected lights at the circuits nor was it possible to physically access fixtures to install time-of-use loggers.

DNV KEMA obtained an updated spreadsheet from the County of Alameda showing the fixture locations, pre and post wattages, and quantities (Figure 51). This spreadsheet was used to reference each fixture during the site visit.

Figure 51: Updated Table Obtained From Site Contact Showing Lighting Locations, Quantities, Pre Fixture Wattages, and Post Fixture Wattages

	Facility Name	Facility Where Equipment Installed	Drawing ID	Fixture ID	Existing Equipment	Proposed Equipment	Estimated Load Reduction (%) (if applicable)	Number of Units
1	Santa Rita Jail	Back of HU's Outdoor 60' & 80' High Mast	(S) E1.03	502	HPS1000	(2) IND 250 (540w) Kit	53.8%	136
4	Santa Rita Jail	Exteriors of Housing units wall packs	(H) E2.02	504	HPS400W	IND150 (158w)	73.8%	72
5	Santa Rita Jail	Exterior Core Bldg & Service Bldg front & back	(S) E2.01-E2.05	505	HPS400W	IND150 (158w)	73.8%	35
6	Santa Rita Jail	Exterior Core Bldg & Minimum yard	(C) E2.07 - E2.11	506	HPS400W	IND150 (158w)	73.8%	8
8	Santa Rita Jail	Quasi Yard Housing	(H) E2.02	508	HPS250 W	IND120 (126w)	78.0%	90
13	SRJ Brown Warehouse	Highbay Fixtures	N./A	BRN400	HPS400W	IND150 w/ M.Bracket	68.5%	20
11	SRJ Blue Warehouse	Highbay Fixtures	N/A	BW400	HPS400W	IND150 w/ M.Bracket	73.8%	24
15	SRJ Firing Range	Firing Range B-F	N/A	FR 101	H1000W	IND120 Fixture	87.8%	17
Totals								402

Source: Information provided to DNV KEMA for analysis

Site findings & Analysis

DNV KEMA was able to physically verify all of the new lights with the exception of the Blue Warehouse. The Blue Warehouse was closed for inspection at the time of the site visit and access was not possible due to security restrictions. However, the site contact indicated that the

retrofit was also completed at that facility as well and DNV KEMA accepted that as confirmation for the installation.

At the facilities where physical verification was completed, all lights were installed and operating as reported with the exception of the Quasi Yard Housing. A total of 90 units were claimed for this location but inspection showed a total of 108 units. When this was pointed out, the site contact concluded that the contractor miscounted these fixtures.

After physical verification of the lighting was completed, DNV KEMA inquired about the hours of operation of the lights pre and postretrofit. The site contact indicated that all exterior lights were on photocell control while fixtures at the two warehouses were on timer control. The "Brown Warehouse" was always on timer control and did not change after the retrofit. In contrast, the "Blue Warehouse" was on 24 hour operation prior to the retrofit but after the retrofit, a timer was installed that allowed the staff to turn on the lights on an as needed basis.

Energy savings were calculated using pre and postretrofit wattages, quantities, and annual hours of operation. The hours of operation used in the project files were verified with the site contact and were considered reasonable. There are no changes in the hours of operation in the ex post calculations. The ex post calculations are provided in Table 134 below.

Table 134: Ex Post Energy Savings Calculations

	Preretrofit Conditions				Postretrofit Conditions				Calculations			
Lighting Location	Existing Fixture Type	Qty	kW/ Fixture	Annual Hours	New Fixture Type	Qty	kW/ Fixture	Annual Hours	Demand Savings, kW	Preretrofit kWh	Postretrofit kWh	Energy Savings, kWh
High Mast Lighting	HPS 1000W	136	1.100	4,398	IND250 x2	136	0.540	4,398		657,941	322,989	334,952
Housing Units Wallpack	HPS 400W	72	0.465	4,398	IND150	72	0.158	4,398		147,245	50,032	97,213
Service& Core Bldg	HPS 400W	35	0.465	4,398	IND150	35	0.158	4,398		71,577	24,321	47,257
Exterior of Core Bldg	HPS 400W	8	0.465	4,398	IND150	8	0.158	4,398		16,361	5,559	10,801
Quasi Yard Housing	HPS 250W	108	0.295	4,398	IND120	108	0.126	4,398		140,120	59,848	80,272
Brown Warehouse	HPS 400W	20	0.465	3,846	IND 150	20	0.158	3,846	6.1	35,768	12,153	23,615
Blue Warehouse	HPS 400W	24	0.465	8,760	IND 150	24	0.158	1,762	7.4	97,762	6,682	91,080
Ranges B-F	H 1000W	17	1.000	4,398	IND120	17	0.126	4,398		74,766	9,421	65,345
								Total	13.5			750,535

Source: DNV KEMA analysis

Savings Results

Total energy savings for this site is 750,535 kWh and 13.5 kW of demand savings. Of this total, 114,695 kWh are from the interior lighting while 635,841 kWh are from the exterior lighting. The ex post results are also shown with the ex ante estimates in Table 132 for comparison.

Discussion

The energy savings for this project is 106 percent of the ex ante reported value. The slightly higher energy savings are due to the additional fixtures in the Quasi Yard Housing which were not accounted for in the ex ante calculations. DNV KEMA found 108 fixtures were installed versus the 90 fixtures shown in the ex ante calculations.

Ex Post Life-cycle Savings

Typically, energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

In the case for the exterior light fixtures, there is no established standard practice so only the early replacement baseline is used to calculate life-cycle savings. Expected EUL values for outdoor lighting fixtures is 15 years according to an ENERGY STAR publication on induction lighting technology.[31] For the interior lights, DNV KEMA assumed the pre-existing condition was already code standard. Therefore, only the early replacement baseline is used to calculate life-cycle savings. Details of this calculation are shown in Table 135.

Table 135: Values Used in Life-cycle Savings Calculations by Measure

Measure	Electric Energy (kWh)	Demand Savings (kW)	Gas Energy (Therms)	EUL	RUL
Exterior Lighting	635,841	0.0	0	15	1
Interior Lighting	114,695	13.5	0	15	1

Source: DNV KEMA analysis

31 ENERGY STAR, ENERGY STAR Challenge Participant Story, 2010. http://www.energystar.gov/index.cfm?fuseaction=challenge.showChallengeStory&ch_id=9892, accessed 1/16/2013.

The life-cycle savings for this site considering the EUL is calculated at 11,258,031 kWh. Table 136 below shows the life-cycle savings by year for these measures.

Table 136: Life-cycle Savings

Life-cycle Year	Calendar Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	750,535	13.5	0
2	2012	750,535	13.5	0
3	2013	750,535	13.5	0
4	2014	750,535	13.5	0
5	2015	750,535	13.5	0
6	2016	750,535	13.5	0
7	2017	750,535	13.5	0
8	2018	750,535	13.5	0
9	2019	750,535	13.5	0
10	2020	750,535	13.5	0
11	2021	750,535	13.5	0
12	2022	750,535	13.5	0
13	2023	750,535	13.5	0
14	2024	750,535	13.5	0
15	2025	750,535	13.5	0
Life-cycle	Total	11,258,025		0

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

County of Ventura, Fillmore Measures Lighting and HVAC Retrofit (CBG-09-134-C)

Site Summary

The County of Ventura was awarded funds to retrofit outdoor and indoor lighting fixtures at five locations throughout the city of Fillmore. Additional funds were used to replace two HVAC units at the police station.

Ex post energy savings were estimated at 129,194 kWh for this project and represent 92 percent of the ex ante estimates (Table 137). The slightly lower energy savings calculated here were primarily the result of 18 exterior fixtures that were not changed out due to problems with the reflectors and lower SEER value units found for the two HVAC unit replacements. Detailed discussion by measure is provided towards the end of this report.

Table 137: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 – High efficiency HVAC	11,906	Not reported	N/A	8,071	4.3	N/A	68%	N/A
EEM2 – Exterior Lighting	69,309	Not reported	N/A	54,067	0.0	N/A	78%	N/A
EEM3 – Interior Lighting	58,639	Not reported	N/A	67,056	17.5	N/A	114%	N/A
Total	139,854	0.00	0.0	129,194	21.7	N/A	92%	N/A

Source: DNV KEMA analysis

The overall results from Table 137 yield a life-cycle energy savings of 1,937,910 kWh. Table 138Life-cycle savings were calculated relative to the pre-existing condition for the full EUL of the equipment.

Table 138: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1	1,937,910	325.5	0.0
Baseline 2	1,839,868	274.1	0.0

Source: DNV KEMA analysis

Project Description

This project was for the retrofit of interior lighting fixtures at four buildings throughout the City of Fillmore, an exterior lighting retrofit for the city promenade, and two HVAC replacements at the police station. The project affected the senior center, police department, fire department, city hall and the city hall promenade.

The pre-existing interior fixtures were primarily of the first generation T8 variety which housed 32 Watt linear fluorescent bulbs. The project replaced this system with a fifth generation T8 system. Occupancy sensors were also installed on a number of fixtures.

Pre-existing lighting for the building exteriors and the promenade were composed of MH or other incandescent type fixtures which were replaced with higher efficiency (LED, induction, or T8) lighting.

There were two HVAC units at the police department described as over 20 years old that were replaced with higher efficiency units.

Ex Ante Savings

EEM1: High efficiency HVAC – Energy savings were calculated using the EECBG Energy Efficiency Calculator to project the HVAC energy usage and savings. This calculator assumes an HVAC unit with a SEER 7 is replaced with an HVAC unit of SEER 16. Total full load hours of operation are estimated at around 1,747 hours. The algorithm uses the equation below to determine energy consumption for the baseline and efficient cases. Energy savings are the difference in energy consumption between these two cases.

$$Energy = \frac{Tons}{SEER \times 1{,}000} \times EFLH$$

Where *Energy* is the annual energy consumption, *Tons* is the unit cooling capacity rating in Btu/h, *SEER* is the seasonal energy efficiency rating, and *EFLH* is the estimated full load operating hours of the unit for the entire year.

EEM2 & 3: Exterior and Interior Lighting – Energy savings were calculated using standard spreadsheet methods which took into account the pre and postretrofit fixture wattages, quantity, and hours of use. The hours of use were estimated and ranged from 500 hours per year for low use fixtures to 8,760 for high use fixtures such as exit signs.

Project Evaluation

A DNV KEMA field engineer visited the project's sites on January 25th, 2012 to verify measure installation and install time-of-use photocell data loggers for determining lighting hours of operation. In addition, an amp logger was installed at one of the HVAC units at the police station to determine power consumption over a six week period. Power of the HVAC unit is determined from the current (amperage) data by using the power and power factor reading taken from a spot power measurement at the time of the logger installation.

Table 139: Monitoring Details

Monitored Equipment	Logger Type	Measurement Type	Measurement Interval	Duration
(8) Light fixtures	DENT TOU lighting loggers	On/Off (time-of-use)	Continuous	6 weeks
(1) HVAC heat pump	Microstation amp logger	Amps	1 minute	6 weeks

Source: DNV KEMA analysis

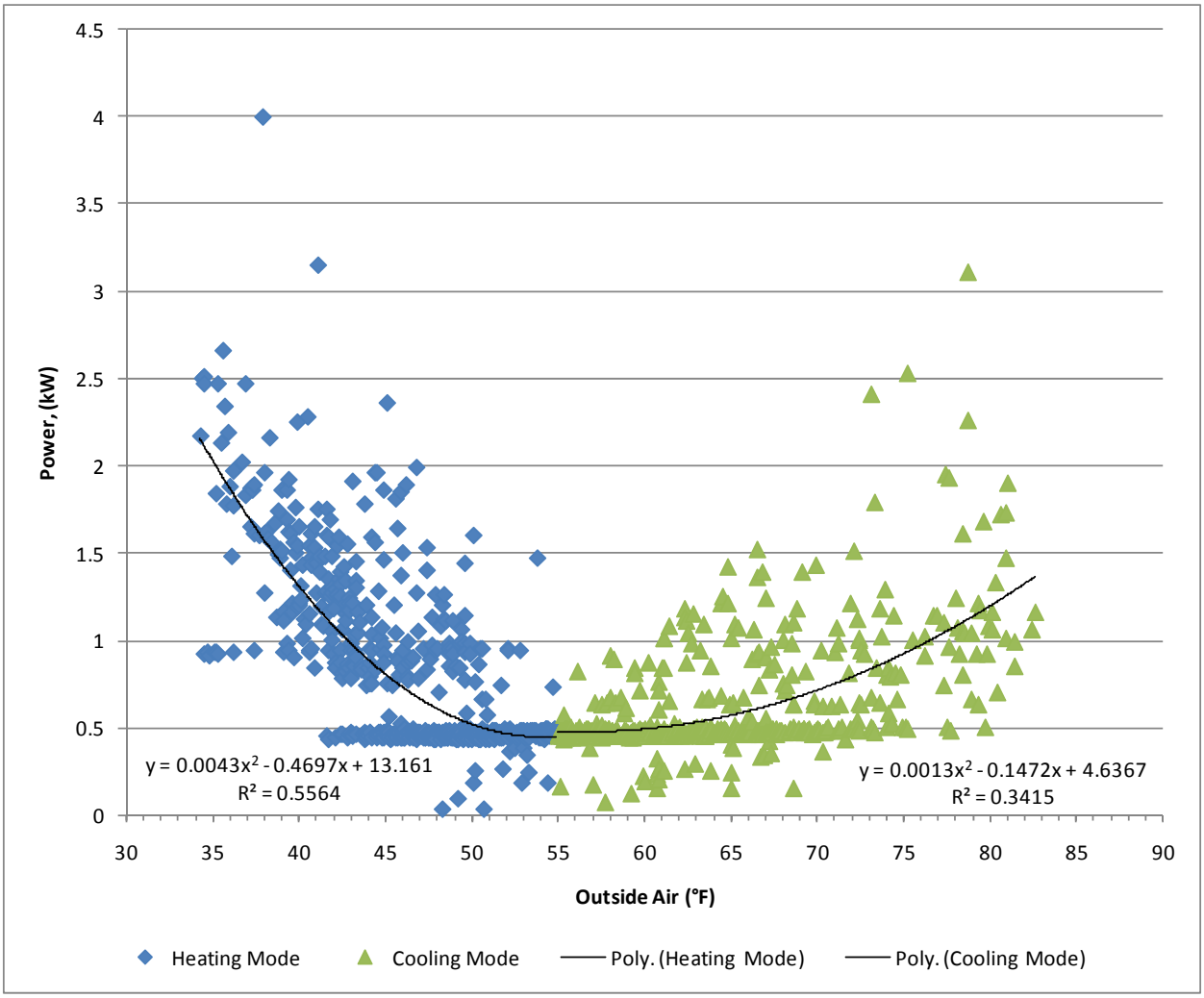
DNV KEMA obtained an updated spreadsheet from the project manager responsible for implementation of the measures which showed fixture locations, pre and post fixture wattages, and quantities. This spreadsheet was used to reference each fixture during the site visit. Select fixture groups were monitored to determine time-of-use. These fixtures were selected based on the relative contribution of the energy savings to the overall project. The higher the energy savings, the more likely the fixture was chosen for monitoring.

EEM1 - High Efficiency HVAC

Two new three ton units were found at the police department. The first unit was a direct expansion condenser unit rated at SEER 14 based on the model number. The second unit was a three ton heat pump rated at SEER 15 based on the model number. This is in contrast to the SEER 16 units specified in the calculations for the efficient case HVAC units. The amp logger was placed at the heat pump unit and monitored the unit for six weeks.

Ex post energy savings were estimated using 5°F weather bins in conjunction with using building loads estimated from a regression analysis of the logged data at the heat pump. Since data logging occurred during both cold and warm periods, the energy consumption of the heat pump for both periods can be analyzed. The following is the regression model taken from the logger which shows energy consumption at different outside air temperatures.

Figure 52: Regression Data Showing Cooling and Heating Energy Consumption for Three Ton Heat Pump



Source: DNV KEMA analysis

Based on the regression data, temperature bins below 55 are considered heating while temperatures above that are considered in the cooling range. TMY3 weather from Burbank was used to normalize the HVAC energy consumption and was the closest available station to Fillmore. The spreadsheet model considers the hours of operation along with flags for the heating/cooling months. The latter was necessary so that hours during the summer are not erroneously used in the heating application when cooling is expected. Actual efficiencies of the new HVAC units were used in the analysis. To determine baseline energy consumption, the standard Title 24 minimum efficiencies at the time the unit was assumed to be installed were determined and a 10 percent degradation factor assumed; this resulted in values for the unit efficiencies of SEER 7.8. The general values used in the analysis are summarized in Table 140 below. This measure saved 8,071 kWh of energy.

Table 140: HVAC Analysis Details

Parameter	Ex Ante Values	Ex Post Values
Methodology	Standard equation using EFLH, SEER, and unit tonnage	Bin analysis using regression data from post monitored usage
Baseline SEER	SEER 7, but total energy assumed 10% more according to calculations	SEER 7.8[32]
Efficient Case SEER	SEER 16	SEER 14 and 15[33]
Total HVAC tonnage	6	6
EFLH	1,746 hours; heating from heat pumps not accounted for	1,829 equivalent full load hours based on monitored data for cooling; 326 equivalent full load hours for heating
Energy Savings	11,906 kWh	8,071 kWh

Source: DNV KEMA analysis

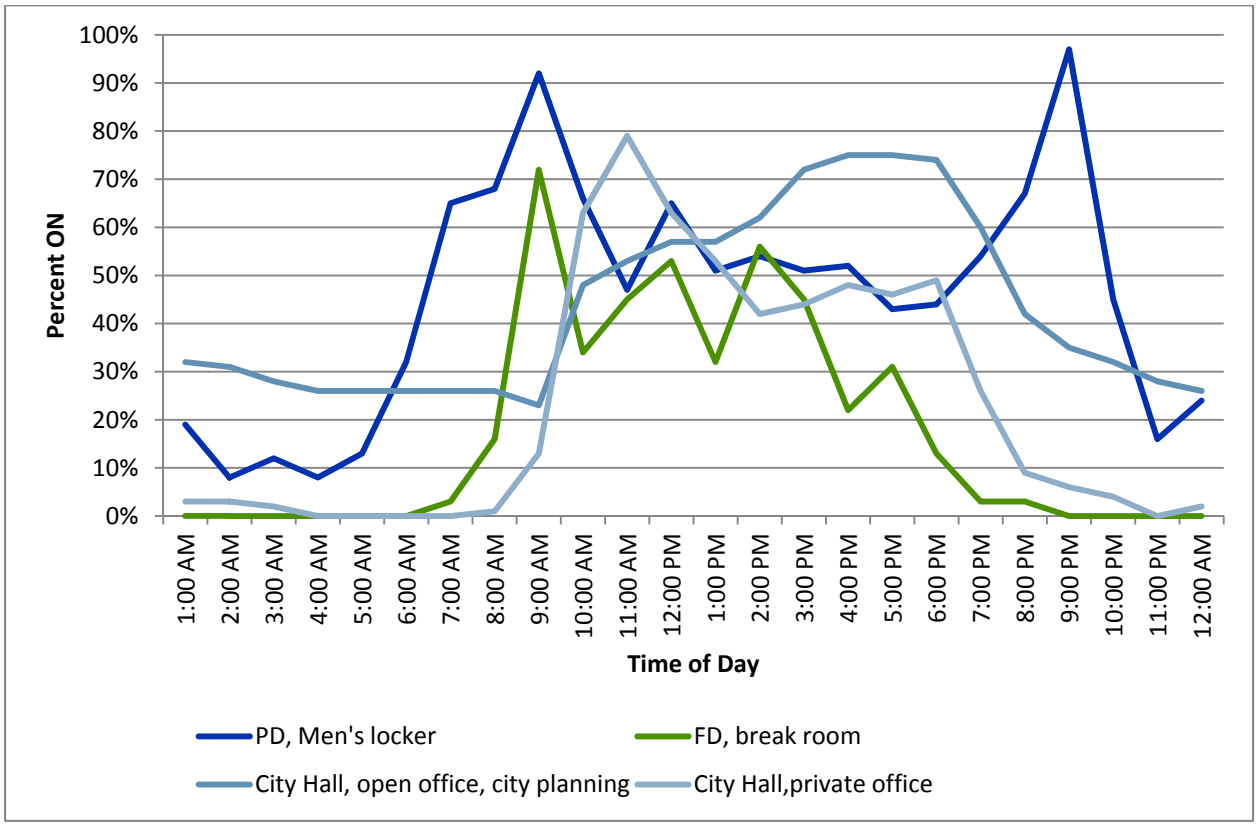
EEM2 & 3 – Exterior and Interior Lighting Retrofit

DNV KEMA was able to physically verify the installation of all new interior light fixtures using the updated spreadsheet provided by the implementers as a cross reference. The quantities and fixture types matched what was described with only few minor differences. The lighting loggers installed at the fixtures shows some time-of-use differences at different buildings and across different space types (Figure 53).

32 Based on 1985 Title 24 and 10% degradation factor.

33 From model number lookup.

Figure 53: Weekday Time-of-use Profile for Select Fixtures at Police Station, Fire Department, and City Hall – Total of 8 Monitored – Only 4 Shown for Illustrative Purposes



Source: DNV KEMA analysis

Overall, the time-of-use data in Figure 53 translated to the following annual hours of use for key fixtures that contributed the most energy savings for this measure.

Table 141: Estimated Annual Hours of Use for Select Fixtures Based on Lighting Logger Data

Fixture Location/Description	Annual Hours of Use (Hours)
PD, Men's locker	3,762
PD, Sargeant's office	4,548
PD, gang office	1,864
FD, break room	1,171
FD, training room	903
City Hall, open office, city planning	3,132
City Hall, private office	1,637
City Hall Open Area, Admin	5,222

Source: DNV KEMA analysis

Occupancy sensors were also found as described. For the analysis, fixtures that were controlled by an occupancy sensor were given a 20 percent credit in energy savings via adjusting the hours of operation in the baseline case. For example, if the logger shows a total annual time-of-use of 800 hours and the fixture was controlled by an occupancy sensor, the baseline time-of-use would be 1,000 hours for that fixture.

Energy savings were calculated using pre and post fixture wattages, quantities, and hours of use from the data loggers. Overall, the revised hours of use from the data loggers resulted in a 15 percent increase in energy savings for the interior lights compared to the ex ante calculation. Ex post energy savings for this measure is estimated at 67,056 kWh.

In contrast, energy savings for the exterior lights were revised downwards by 22 percent because 18 of the 70 promenade lights were not installed due to issues with the reflectors. Since these lights make up the bulk of the energy savings for the exterior lights, the energy savings decreased in similar proportions. Energy savings for the exterior lights is 54,067 kWh and were calculated similar to the interior lights.

Savings Results

Considering the implementation of all three EEMs, this site saved 129,194 kWh of electric energy and 21.7 kW of demand power. Table 137 breaks down the ex post energy savings by measure. The ex ante energy savings are also provided for comparison.

Discussion

EEM1 – High Efficiency HVAC

Fundamentally, ex ante and ex post energy savings calculations applied a different methodology to determine savings so it is expected that the energy savings estimates will differ slightly. However, in this case, the ex post estimate is 68 percent of ex ante projection, a large difference that cannot be primarily attributed to differences in calculation methodologies. From examination of the parameters used in the calculations, the reason for this difference is due to the HVAC unit efficiencies used in the calculations for both the baseline and efficient cases.

There were a total of two units installed as part of the project scope, with a cooling capacity rating of three tons apiece. The model numbers for the HVAC units collected during the site visit show an efficiency rating of SEER 14 for one and SEER 15 for the other. This is in contrast to the ex ante assumption of SEER 16.

In addition, no information (such as model number) was available for the pre-existing units. In this case, the ex ante calculations assumes that the pre-existing unit efficiencies were at SEER 7 and was further de-rated in the calculations to account for degradation. According to the project files, the units were described as over 20 years old but it is uncertain what the actual operating efficiencies of the unit was at the time of replacement. DNV KEMA used a more conservative SEER value of 8.65 and de-rated this value by 10 percent to a SEER value of 7.8. This value is supported by minimum Title 24 efficiency standards around the time the pre-existing unit was expected to be initially put in service. The revised baseline SEER and efficient case SEER values for the two HVAC units results in lower energy savings for this measure.

Note also, that one of the units is a heat pump and is not expected to operate all year. However, the ex ante calculation ignores this. In contrast, the ex post energy savings methodology accounts for this fact. Furthermore, the overall ex post methodology employs actual data collected from the heat pump unit and this is expected to yield more accurate results in the energy savings algorithm.

EEM2 – Exterior lighting

Exterior lighting energy savings are only 78 percent of what is predicted in the ex ante estimates. This is because 25 percent of promenade fixtures were not replaced due to problems with the reflectors. The ex ante estimates were not yet updated to reflect this. The energy savings for each of these fixtures are relatively high due to the conversion from a 190 Watt MH system to a 55 Watt LED system. The fixtures that were not replaced reduced the energy savings by 10,643 kWh.

There is also an error in the calculation spreadsheet which shows that the 55 Watt LED lights have system wattages of only 40 Watts and is an obvious mistake.

EEM3 – Interior lighting

Interior lighting energy savings are 114 percent of what is predicted in the ex ante estimates. This is largely due to revised hours of operation taken from the data loggers which shows slightly different hours of use for key fixtures that make up the majority of the energy savings for this measure. A difference of 14 percent is reasonable given the fact that the ex ante values are mostly estimated and may not reflect the hours of use in practice.

The hard copy spreadsheet provided to DNV KEMA at the site visit also has what appears to contain an error in the proposed hours of use for the Senior Center, but it is unclear whether the error is carried over to the energy savings summary. The electronic spreadsheet copy was not provided for review and it is possible that this data entry error may have contributed to the difference in energy savings.

Ex Post Life-cycle Savings

Typically, energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

In the case for the HVAC measure, the units have already exceeded its useful life. For Baseline 1, DNV KEMA used the code standard efficiency at the time the old unit was expected to be installed (mid 1980's). For Baseline 2, the first year energy savings assumes the existing unit

efficiency but for the rest of the EUL, code standard efficiency (SEER 13) were used to calculate life-cycle savings.

In the case for the exterior and interior lighting measures, DNV KEMA assumed the pre-existing condition was already code standard. Therefore, only the early replacement baseline is used to calculate life-cycle savings. Details of this calculation are shown in Table 142.

Table 142: Values Used in Life-cycle Savings Calculations by Measure

Measure	Baseline 1		Baseline 2		EUL (years)	RUL (years)
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)		
EEM1 – High Efficiency HVAC	8,071	0.0	1,068	0.0	15	0.0
EEM2 – Exterior Lighting	54,067	0.0	54,067	0.0	4	0.0
EEM3 – Interior Lighting	67,056	0.0	67,056	0.0	4	0.0

Source: DNV KEMA analysis

When only considering Baseline 1 over the entire life of the measure, this project yields an estimated energy savings of 1,937,908 kWh (Table 143). However, if the dual baseline is used, the life-cycle savings comes to 1,839,874 kWh. Table 143 tabulates the energy savings by year starting with 2011 using this dual baseline.

Table 143: Baseline 1 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	129,194	21.7	0.0
2	2012	129,194	21.7	0.0
3	2013	129,194	21.7	0.0
4	2014	129,194	21.7	0.0
5	2015	129,194	21.7	0.0
6	2016	129,194	21.7	0.0
7	2017	129,194	21.7	0.0
8	2018	129,194	21.7	0.0
9	2019	129,194	21.7	0.0
10	2020	129,194	21.7	0.0

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
11	2021	129,194	21.7	0.0
12	2022	129,194	21.7	0.0
13	2023	129,194	21.7	0.0
14	2024	129,194	21.7	0.0
15	2025	129,194	21.7	0.0
16	2026	0	0.0	0.0
Life-cycle	Total	1,937,910	325.5	0.0

Source: DNV KEMA analysis

Table 144: Baseline 2 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	129,194	22	0.0
2	2012	122,191	18.0	0.0
3	2013	122,191	18.0	0.0
4	2014	122,191	18.0	0.0
5	2015	122,191	18.0	0.0
6	2016	122,191	18.0	0.0
7	2017	122,191	18.0	0.0
8	2018	122,191	18.0	0.0
9	2019	122,191	18.0	0.0
10	2020	122,191	18.0	0.0
11	2021	122,191	18.0	0.0
12	2022	122,191	18.0	0.0
13	2023	122,191	18.0	0.0
14	2024	122,191	18.0	0.0
15	2025	122,191	18.0	0.0
16	2026	0.0	0.0	0.0
Life-cycle	Total	1,839,868	274	0.0

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

City of Oxnard, Ventura County, CA (CBG-09-134-E)

Site Summary

The County of Ventura applied for EECBG funds which included energy efficient lighting measures at the Fire Station #51 and the Ventura County Health Care Agency buildings within the City of Oxnard, California. The majority of EECBG funded lighting equipment includes lower power ballasts and T8 lamps for interior fluorescent fixtures, motion sensor lighting controls for interior fixtures, LED elevator car lighting, screw base CFL lamps, T5 high output fixtures and lamps for exterior parking lot lighting, and exterior LED floodlighting.

DNV KEMA performed site visits at both of the county facilities within Oxnard that received EECBG funded energy efficiency retrofits. During the site visits, DNV KEMA verified a large sample of the installed quantity of fixtures, bulbs and controls, as well as fixture and bulb wattages.

Spreadsheet analysis was used to estimate energy savings for all lighting upgrades using a combination of site findings and project documentation reviews. The analysis yielded an overall annual electric energy savings of 141.7 percent when compared to ex ante estimates. The energy and power savings by measure are provided in Table 145.

Table 145: Energy Savings Summary by Measure Category

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Maximum Demand Reduction (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Maximum Demand Reductio n (kW)	Gas Energy (Therms)	Electric	Gas
Fire Station #51: Lighting	14,667	3.10	N/A	12,644	2.55	N/A	86.2%	N/A
Health Care Agency: Lighting	110,718	18.51[34]	N/A	165,042	14.66	N/A	149.1%	N/A
Total	125,385	21.61	N/A	177,686	17.21	N/A	141.7%	N/A

Source: DNV KEMA analysis

34 No demand savings was listed in the project database provided to KEMA. This value was obtained from the ex ante savings calculation documents.

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses *minimally code-compliant* conditions or *standard practice* as the baseline once the RUL of the pre-existing equipment is exceeded.

The overall results from Table 145 yields a life-cycle energy savings of 2,665,290 kWh, life-cycle demand savings of 258 kW-years, when considering Baseline 1 conditions as shown in Table 146. Using a dual baseline defined as Baseline 2, the life-cycle savings total 2,665,290 kWh, 258 kW-years, as shown in Table 146.

Table 146: Ex Post Life-cycle Savings Totals

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1	2,665,290	258	-
Baseline 2	2,665,290	258	-

Source: DNV KEMA analysis

Project Description

Measure 1: Fire Station #51 Lighting

This measure involved the replacement of nearly all lighting fixtures at the county fire station facility. The planned retrofits, organized by retrofit fixture type, are shown in Table 147 below.

Table 147: Planned Measure 1 Lighting Retrofits

Existing Fixture Description	Existing Fixture Watts	Fixture Count	Annual Oper. hours	Annual kWh Consump.	Retrofit Fixture Description	Retrofit Fixture Watts	Annual kWh Consump.	Sensor Savings @ 15%	Annual kWh Savings	Demand Savings, kW
2x2 U-Lamp T8	59	10	4,000	2,360	2' 3-Lamp T8	37	1,480		880	0.22
4' 2-Lamp T8	59	36	4,000	8,496	4' 2-Lamp Supersaver T8	42	6,048	907	3,355	0.61
2' 1-Lamp T8	28	7	1,000	196	2' 1-Lamp Supersaver T8	16	112	17	101	0.08
3-Lamp T8	88	11	4,000	3,872	2-Lamp Supersaver T8	48	2,112	317	2,077	0.44
4-Lamp CFL High Bay	168	12	4,000	8,064	8' 4-Lamp T8	95	4,560	684	4,188	0.88
60W Incandescent	60	4	4,000	960	23W CFL	23	368		592	0.15
50W MH Floodlights	79	3	4,380	1,038	18W LED Floodlights	18	236		801	0.18
100W MH Bollard	128	1	4,380	561	36W LED Bollards	36	158		403	0.09
400W MH Exterior	458	2	4,380	4,012	4' 4-Lamp T5HO	234	2,050	307	2,270	0.45
Totals		86		29,559	Totals		17,124	2,232	14,667	3.10

Source: DNV KEMA analysis

Measure 2: Ventura County HCA Lighting

This measure involved the replacement of nearly all lighting fixtures at the county Health Care Agency facility. The planned retrofits, organized by retrofit fixture type, are shown in Table 148 below.

Table 148: Planned Measure 2 Lighting Retrofit Groups

Existing Fixture Description	Existing Fixture Watts	Fixture Count	Annual Oper. hours	Annual kWh Consump.	Retrofit Fixture Description	Retrofit Fixture Watts	Annual kWh Consump.	Sensor Savings @ 15%	Annual kWh Savings	Demand Savings, kW
4' 3-Lamp T8	86	652	4,433	248,567	4' 3-Lamp T8	64	184,980	27,747	91,334	14.34
2' 2-Lamp U T8	59	32	4,433	8,369	2' 3-Lamp T8	37	5,249	788	3,909	0.70
2-Lamp T12	72	8	1,000	576	2-Lamp T8	41	328	49	297	0.25
2-Lamp T8	59	2	1,000	118	2-Lamp T8	41	82	12	48	0.04
250W MH	295	17	4,380	21,966	2' 4-Lamp T5HO	108	8,042	1,206	15,130	3.18
Totals		711		279,596	Totals		198,681	29,802	110,718	18.51

Source: DNV KEMA analysis

Ex Ante Savings

Ex ante project savings were calculated using a spreadsheet analysis method. This method used fixture wattage, fixture quantity, and assumed annual operating hours for a given fixture type and application to determine annual electrical energy consumption for the existing fixtures and the planned lighting retrofits. The annual kWh savings is calculated as the difference in annual kWh consumption between the existing fixtures and the retrofitted fixtures. The kWh savings calculations are represented by the following two equations:

$$Annual\ kWh_{Existing\ or\ Retrofit} = (\#_{Fixtures} \times kW_{Fixture} \times Hours_{annual})_{Existing\ or\ Retrofit}$$

Where, ,

$$kWh\ Savings = Annual\ kWh_{Existing} - Annual\ kWh_{Retrofit}$$

Ex ante demand reduction was calculated using a similar analysis method. First, the total power consumption for an existing or retrofitted fixture type and application is calculated using the fixture wattage and fixture quantity. Demand reduction is then calculated to be the difference in power consumption between the existing and the retrofitted fixture type and application. The kW demand reduction calculations are represented by the following two equations:

$$Maximum\ Demand\ Reduction\ (kW) = kW_{Existing} - kW_{Retrofit}$$

Where,

$$kW_{Existing\ or\ Retrofit} = (\#_{Fixtures} \times kW_{Fixture})_{Existing\ or\ Retrofit}$$

Measure 1: Fire Station #51 Lighting

Total Measure 1 ex ante annual kWh savings was calculated to be 14,667 kWh with an ex ante maximum demand reduction of 3.10 kW.

Measure 2: Ventura County HCA Lighting

Total Measure 1 ex ante annual kWh savings was calculated to be 110,178 kWh with an ex ante maximum demand reduction of 18.51 kW.

Project Evaluation

A DNV KEMA field engineer visited the project sites on August 28th, 2012 to verify the measure installations and gather data on equipment model numbers, quantities, and lighting control schemes. Table 149 shows the ex post values of major lighting groups that were verified for Measure 1.

Table 149: Measure 1 Verified Lighting Retrofits

Fixture Location	Existing Fixture Description	Existing Fixture Watts	Existing Fixture Count	Annual Oper. hours	Annual kWh Consump.	Retrofit Fixture Description	Retrofit Fixture Watts	Retrofit Fixture Count	Annual Oper. Hours	Annual kWh Consump.	Annual kWh Savings
Fire Station# 51: Exterior	25' Pole	458	2	4,380	4,012	Area/parking lot fixture with 4ft 54 watt T5HO lamps (up to 4 lamps) with integrated high-low motion sensor	254	2	4,380	2,225	1,787
Fire Station #51: Garage	44 CFL High Bay Fixtures	168	12	3,480	7,016	Surface mounted, prismatic lens, (4) 28 watt T8 lamps and programmed start ballast	82	12	3,480	3,424	3,591
Fire Station# 51: Offices, Work Area	2x4 27Cell PB	89	9	2,738	2,193	3 lamp fixture with sheet metal kit, (2) 28 watt lamps and programmed start NBF**ballast	51	9	2,738	1,257	936

Fixture Location	Existing Fixture Description	Existing Fixture Watts	Existing Fixture Count	Annual Oper. hours	Annual kWh Consump.	Retrofit Fixture Description	Retrofit Fixture Watts	Retrofit Fixture Count	Annual Oper. Hours	Annual kWh Consump.	Annual kWh Savings
Fire Station# 51: Interior Living Space, Offices, Lockers	Various F32T8 fixtures	64	16	2,794	2,844	Fixture with (2) 28 watt lamp and programmed start LBF* ballast	41	12	2,803	1,379	1,465
Fire Station# 51: Exterior	100 W MH Wallpack	128	1	4,380	561	40 Watt induction lamp	40	1	4,380	175	385
Fire Station #51: Entry, Hall	FO31U6T8 2x2 RT	60	9	3,000	1,620	Fixture with (3) F17T8 lamps and programmed start LBF ballast	38	9	3,000	1,026	594
Fire Station# 51: Interior Living Space	6" RC	26	17	3,000	1,326	18-26W SS CFL	21	17	3,000	1,071	255
Fire Station #51: Beds 1 Ea x 6 Rms	2x4 RT Prism	60	12	1,820	1,310	Fixture with (1) 28 watt lamp and programmed start LBF* ballast	21	12	1,820	459	852
Fire Station# 51: Exterior	50W MH Floodlights	72	2	4,380	631	20W LED Floodlights on Existing Mounting	20	2	4,380	175	456

Fixture Location	Existing Fixture Description	Existing Fixture Watts	Existing Fixture Count	Annual Oper. hours	Annual kWh Consump.	Retrofit Fixture Description	Retrofit Fixture Watts	Retrofit Fixture Count	Annual Oper. Hours	Annual kWh Consump.	Annual kWh Savings
Fire Station# 51: Interior Living Space	Incandescent Lamps in Table Lamps	60	4	3,000	720	Screw base CFL Lamps in Table lamps	19	4	3,000	228	492
Fire Station# 51: Interior	2' Bed Light	20	7	1,820	255	Fixture with (1) 2' 17 watt lamp and programmed start LBF* ballast	14	7	1,820	178	76

Source: DNV KEMA analysis

During the on-site visit, DNV KEMA verified installation for a sample of 87 of the total 138 fixture retrofits at the facility. This sample represents 63 percent of the total retrofitted fixture quantity and 74 percent of the claimed savings. Table 150 illustrates the major lighting retrofits that were verified, but does not include all the retrofits that were performed or verified under Measure 1. Complete ex ante and ex post calculation spreadsheets for all lighting retrofits have been included as an appendix in this report.

Measure 2: Ventura County HCA Lighting

This measure involved the replacement of nearly all lighting fixtures at the county Health Care Agency facility. Below, Table 150 shows the ex post values of major lighting groups that were verified for Measure 2.

Table 150: Measure 2 Verified Lighting Retrofits

Fixture Location	Existing Fixture Description	Fixture Watts	Fixture Count	Annual Oper. hours	Annual kWh Consump.	Retrofit Fixture Description	Fixture Watts	Fixture Count	Annual Oper. Hours	Annual kWh Consump.	Annual kWh Savings
2220 E Gonzales Ave: Exterior (parking lot)	MH250U ROUND SHOEBOX	295	17	4,380	21,966	FP54 T5 4 lamp 4ft 50wattT5ho with integrated motion sensor	220	17	2,440	9,126	12,840
2220 E Gonzales Ave: Lobby, Kitchens, Main Ceilings	6L F32T8 2X4 RECESSED	180	148	8,760	233,366	6L F28T8 TANDEM WIRE, 2L & 4L BALLAST IN 1 FIX W/ LOW POWER PROGRAM START BALLAST	120	148	7,475	132,756	100,610
2221 E Gonzales Ave: Office	3L F32T8 2X4 Recessed Fixtures	120	1	4,380	526	4L F28T8 Fixture with (4) 28 watt lamp and programmed start LBF* ballast	80	1	4,380	350	175
2220 E Gonzales Ave: Lobby, Kitchens, Main Ceilings	3L F32T8 2X4 RECESSED	90	23	4,380	9,067	3L F028 FIXT W (1) 1L AND (1) 2L LOW POW PROGRAM START BALLAST	60	23	4,098	5,655	3,411
2221 E Gonzales Ave: Interior	1X4 WRAP	90	19	4,380	7,490	3L F028T8 Fixture with (3) 28 watt lamp and programmed start LBF* ballast	60	19	4,380	4,993	2,497

Fixture Location	Existing Fixture Description	Fixture Watts	Fixture Count	Annual Oper. hours	Annual kWh Consump.	Retrofit Fixture Description	Fixture Watts	Fixture Count	Annual Oper. Hours	Annual kWh Consump.	Annual kWh Savings
2220 E Gonzales Ave: Corridors	F32T8U6 2X2 RECESSED Fixtures	60	32	4,380	8,410	F017T8 Fixture with (3) 2' 17 watt lamp and programmed start LBF ballast	36	32	4,380	5,046	3,364
2220 E Gonzales Ave: Exterior	WALL MOUNT MH100UMED	135	6	4,380	3,548	LED floodlight, 40 watt on existing mounting	36	6	4,380	946	2,602
2221 E Gonzales Ave: Exterior	MH70UMED Bollard Fixtures	105	10	4,380	4,599	32W CFL Retrofit	32	10	4,380	1,402	3,197
2220 E Gonzales Ave: Elevator	RECESSED Q20MR16	25	6	4,880	732	6W LED MR16	6	6	4,880	176	556

Source: DNV KEMA analysis

During the on-site visit, DNV KEMA sampled 262 of the total 358 fixture retrofits at the facility. This sample represents 73 percent of the total retrofitted fixture quantity and 116.7 percent of the claimed savings. Table 150 illustrates the major lighting retrofits that were verified, but does not include all the retrofits that were performed or verified under Measure 1. Complete ex ante and ex post calculation spreadsheets for all lighting retrofits have been provided to the Energy Commission.

The Measure 2 ex ante analysis identified 201 existing fixtures and 42 retrofit fixtures which errantly listed 9,760 annual operating hours. For the ex post analysis, the annual operating hours for these fixtures was adjusted to 8,760 hours. Annual operating hours for the 157 existing fixtures and 126 retrofit fixtures which operate 12 hours a day were modified from 4,880 to 4,380 annual operating hours.

The ex post lighting measure savings analysis is based upon the same calculation methods as described in the ex ante Savings section with the exception of the maximum demand reduction calculation. Lighting fixtures that normally do not operate during the daytime were identified and excluded from the demand reduction accounting. For Measure 1, fixtures in the following spaces were excluded from the demand savings calculation: bed, closet, exterior, exterior data closet, exterior electrical closet, and patio. For Measure 2, fixtures in the following spaces were excluded from the demand savings calculation: building entrances, electrical room, elevator equipment room, front sidewalk, roof access room, server room, storage, and parking lots.

This analysis yielded the first-year annual energy savings of 177,686 kWh.

The first-year electric demand savings yielded by this analysis was 17.2 kW under Baseline 1 conditions.

Savings Results and Discussion

The project saved 177,686 kWh of electric energy in the first year and represents a realization rate of 141.7 percent for electric energy when compared to the ex ante estimated savings. Furthermore, the project reduced summer on-peak demand by 17.2 kW in the first year, a realization rate of 79.6 percent for maximum demand reduction when compared to the ex ante estimated reduction.

Sources of uncertainty regarding these lighting calculations include the sampling installation verification and assumptions regarding annual operating hours.

DNV KEMA's higher ex post savings estimate for electric energy kWh (141.7 percent) is primarily due to the alteration of retrofits from the original ex ante plan and savings calculation such as the 69 6-Lamp fixture retrofits (133,121 kWh), which save more watts per unit than the planned 3-Lamp retrofits (91,334 kWh), and because the ex post lighting retrofit spreadsheet included greater detail of the lighting inventory and operating schedules than the more generalized ex ante lighting retrofit spreadsheet.

Notably, there were a number of ex ante savings calculations that used 9,760 annual hours of operation when there are only 8,760 hours in a full year. DNV KEMA corrected these errors in their calculation of ex post savings.

DNV KEMA's lower ex post savings estimate for demand reduction (79.6 percent) is due to the fact that the ex ante calculation method for demand savings did not attempt to identify and exclude lighting fixtures that do not operate during the daytime peak demand reduction period.

Ex Post Life-cycle Savings

Energy savings for this program are calculated relative to two established baseline, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

Table 151 displays the first year annual kWh, kW, and therm savings values used to calculate the Baseline 1 life-cycle savings. Table 151 also lists the effective and RUL for each measure that was used in conjunction with the first year energy and power savings values. One the following page, Table 152 presents the electrical energy, electrical demand, and natural gas energy savings according to Baseline 1 conditions for each year the measure is in place up to the end of the measure's EUL. Table 153 presents the yearly life-cycle savings values according to Baseline 2 conditions.

Table 151: Values Used in Ex Post Life-cycle Savings Calculations

Measure	Early Replacement			Expected Replacement			EUL (years)	RUL (years)
	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)	EUL (years)	RUL (years)
Measure 1: Fire Station #51 Lighting	12,644	2.55	N/A	12,644	2.55	N/A	15	1
Measure 2: Health Care Agency Lighting	165,042	14.66	N/A	165,042	14.66	N/A	15	1
Total	177,686	17.21	N/A	177,686	17.21	N/A	-	-

Source: DNV KEMA analysis

Table 152: Baseline 1 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	177,686	17.21	-
2	2013	177,686	17.21	-
3	2014	177,686	17.21	-
4	2015	177,686	17.21	-
5	2016	177,686	17.21	-
6	2017	177,686	17.21	-
7	2018	177,686	17.21	-
8	2019	177,686	17.21	-
9	2020	177,686	17.21	-
10	2021	177,686	17.21	-
11	2022	177,686	17.21	-
12	2023	177,686	17.21	-
13	2024	177,686	17.21	-
14	2025	177,686	17.21	-
15	2026	177,686	17.21	-
Life-cycle	Total	2,665,290 kWh	258.1 kW-years	0 Therms

Source: DNV KEMA analysis

Table 153: Baseline 2 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	177,686	17.21	-
2	2013	177,686	17.21	-
3	2014	177,686	17.21	-
4	2015	177,686	17.21	-
5	2016	177,686	17.21	-
6	2017	177,686	17.21	-
7	2018	177,686	17.21	-
8	2019	177,686	17.21	-
9	2020	177,686	17.21	-
10	2021	177,686	17.21	-
11	2022	177,686	17.21	-
12	2023	177,686	17.21	-

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
13	2024	177,686	17.21	-
14	2025	177,686	17.21	-
15	2026	177,686	17.21	-
Life-cycle	Total	2,665,290 kWh	258.1 kW-years	0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

San Joaquin Valley Air Pollution Control District (CBG-09-135-B), Cities of Madera and Oakhurst

Site Summary

This project involved the retrofit of various types of lighting fixtures throughout 18 facilities located in the cities of Madera and Oakhurst.

Table 154 summarizes the ex ante and ex post savings estimates for this project.

Table 154: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
Lighting projects	433,533	N/A	NA	468,526	120	NA	108%	NA
Total	433,533	N/A	NA	468,526	120	NA	108%	NA

Source: DNV KEMA analysis

Ex ante savings estimates and analysis were not provided for the revised scope of work. The original scope of work called for heating, ventilation, and air-conditioning (HVAC) and lighting measures. The revised scope only includes lighting and appears to be a broader scope of work than originally planned.

The lighting measures, as shown in the contractor's invoices, were determined to be installed and operating as reported. The ex post energy savings were calculated by the evaluation team. However, since no ex ante savings were provided for the revised scope of work, no realization rate was calculated.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

DEER provides an EUL of 15 years for lighting measures. Table 155 provides the life-cycle savings summary.

Table 155: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings	Peak Demand (kW)	Natural Gas Energy Savings
Baseline 1&2	7,027,890	120	N/A

Source: DNV KEMA analysis

Project Description

This project involved the retrofit of various types of lighting fixtures throughout 18 facilities located in the cities of Madera and Oakhurst.

The lighting retrofit consists of more than 4,000 fixtures, including T12 to HPT8 lamp and ballast retrofits, T8 to reduced wattage HPT8, to LED, HPS to LED, HPS to T5 lamp, compact florescent lamps (CFL), occupancy sensors, and exit signs.

Project Evaluation

The evaluation team visited the facility on June 7th, 2012, to verify the installation and operation of the lighting measures.

Lighting Retrofit

The evaluation team surveyed a sample of facilities and inspected examples of each type of lighting fixtures retrofitted. Site staff confirmed each facility's operating hours. No discrepancies were found between the inspected lighting fixtures and those reported in the project's invoicing documentation.

To determine the energy savings for the installed measures, the evaluation team developed a spreadsheet calculation based on the line-item list of the retrofitted fixtures, as reported in the contractor's invoices.

Savings Results

The total annual energy savings for all projects was verified as 468,526 kWh. A non-coincident demand reduction of 120 kW was also realized.

Ex Post Life-cycle Savings

Energy savings were calculated relative to dual baselines. Baselines 1 and 2 are identical for the lighting measure. The life-cycle analysis is based on an EUL of 15 years.

Table 156: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	468,526	120	N/A
2	2013	468,526	120	N/A
3	2014	468,526	120	N/A
4	2015	468,526	120	N/A
5	2016	468,526	120	N/A
6	2017	468,526	120	N/A
7	2018	468,526	120	N/A
8	2019	468,526	120	N/A
9	2020	468,526	120	N/A
10	2021	468,526	120	N/A
11	2022	468,526	120	N/A
12	2023	468,526	120	N/A
13	2024	468,526	120	N/A
14	2025	468,526	120	N/A
15	2026	468,526	120	N/A
Total		7,027,890		N/A

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

San Joaquin Air Pollution Control District (CBG-09-135-E), Avenal Streetlight Replacement and Retrofit

Site Summary

This project contains two measures. The EEM1 involved retrofitting the incandescent lamps in decorative streetlights with LED lamps. The EEM2 replaced HPS streetlight lamps with LED lamps. Table 157 below presents a summary of the energy savings.

Table 157: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
Incandescent to LED retrofit	7,076	9.9	N/A	43,458	9.9	N/A	614%	N/A
EEM2 – HPS to LED replacement	13,104	2.5	N/A	15,348	3.5	N/A	117%	N/A
Total	20,180	12.4	N/A	58,806	13.4	N/A	291%	N/A

Source: DNV KEMA analysis

The ex ante savings estimates indicated seven measures would be installed. Before the M&V plan was written, the evaluation team interviewed the site contact and obtained updated project information. Through interviews with the site contact and review of the contractor's invoices, it was determined that only two measures were installed: decorative LED streetlights and LED streetlights.

For EEM1, the ex post savings are more than double the ex ante savings. No energy savings analysis was provided for the ex ante savings estimates; only the measure type and total estimated savings were provided. The evaluation team verified 110 fixtures with 100 W incandescent lights were retrofitted with 9.8 W LEDs.

For EEM2, no energy savings analysis was provided for the ex ante savings estimate; only the measure type and total estimated savings were provided. The evaluation team verified 24 150 W HPS lamps were retrofitted with 42 W LED lamps.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For the lighting fixture retrofit, the baselines are identical. For the outdoor lighting retrofits, DEER provides an EUL of 15 years. Table 158 presents the life-cycle savings of the project.

Table 158: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline1 & 2	882,090	13.4	N/A

Source: DNV KEMA analysis

Project Description

This project involved retrofitting streetlights throughout the city with LED lamps.

Measure 1 – Decorative LED Streetlights

EEM1 retrofitted 110 fixtures using 100 W incandescent lamps with 9.8 W LED lamps.

Measure 2 – Standard LED Streetlights

EEM2 retrofitted 24 shoebox-style streetlights using 150 W HPS lamps with 42 W LED lamps.

Savings were calculated using the following algorithm:

$$\textit{Annual savings (kWh)} = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Pre-retrofit annual hours of operation for usage group, 4,380 hours/year for ex post analysis
PostRunHrs	= Postretrofit annual hours of operation for usage group (assumed to be the same, as no changes were made to the lighting controls)

Project Evaluation

The evaluation team visited the city on April 30 and May 1 of 2012 to verify the installation of each measure and to verify lighting fixture wattages and hours of operation. The baseline fixture wattages were determined from interviews with the site contact. All fixtures were observed, but LED lamp wattages could not be verified through visual inspection. LED lamp wattages were verified by the site contact and from the contractor's invoices.

Figure 54 and Figure 55 show sample light fixtures surveyed as part of the inspection process.

Figure 54: Decorative Streetlight

Photo Credit: DNV KEMA

Figure 55: LED Streetlight Lamp Close-up

Photo Credit: DNV KEMA

Savings Results

The ex post savings calculation resulted in 58,806 kWh in annual energy savings. Demand savings of 13.4 kW were also realized.

Discussion

On-site verification activities in the city of Avenal found that more decorative street lights than stated in the contractor's invoice and confirmed the number of standard streetlights stated on the contractor's invoice.

Measure 1 – Decorative LED Streetlights

On-site verification activities found that 110 fixtures had been retrofitted with LED lamps instead of the 108 listed in the contractor's invoice. The evaluation team also discovered that the baseline was 100 W incandescent lamps and retrofit lamp wattages are 9.8 W LEDs. The site staff stated that these lights are controlled by a time clock that is adjusted manually. It is adjusted in the fall and spring for daylight savings time as well as few other times over the course of the year to account for longer days in the summer and shorter days in the winter.

The site contact indicated that there is no clear schedule for when this is done or by how much. The evaluation team used an average of 12 hours per day of operation to calculate the energy savings.

Measure 2 – Standard LED Streetlights

On-site verification confirmed that 24 shoebox-style streetlight fixtures had been retrofitted with LED lamps, as described in the project documentation. During an interview, the site contact

provided the baseline and retrofit wattages to the evaluation team and indicated that the lights are controlled by a photo sensor.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1). The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the EEM implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 159 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 159: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	58,806	13.4	N/A
2	2013	58,806	13.4	N/A
3	2014	58,806	13.4	N/A
4	2015	58,806	13.4	N/A
5	2016	58,806	13.4	N/A
6	2017	58,806	13.4	N/A
7	2018	58,806	13.4	N/A
8	2019	58,806	13.4	N/A
9	2020	58,806	13.4	N/A
10	2021	58,806	13.4	N/A
11	2022	58,806	13.4	N/A
12	2023	58,806	13.4	N/A
13	2024	58,806	13.4	N/A
14	2025	58,806	13.4	N/A
15	2026	58,806	13.4	N/A
Total		882,090		N/A

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

San Joaquin Valley Air Pollution Control District (CBG-09-135-F, Corcoran Streetlight and Exterior Lighting Retrofit

Site Summary

This project consists of two measures. The first measure (EEM1) replaced 67 high intensity discharge (HID) streetlight fixtures with light-emitting diode (LED) streetlight fixtures. The second measure (EEM2) retrofitted high-pressure sodium (HPS) wallpacks with induction lamps and drivers as well as retrofitting T12 fluorescent fixtures with T8 lamps and ballasts and replacing incandescent exit signs with LED exit signs. Table 160 presents a summary of the energy savings.

Table 160: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh*)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh*)	Peak Demand (kW*)	Gas Energy (Therms)	Electric	Gas
EEM1 – LED streetlight	33,342	N/A	N/A	36,266	N/A	N/A	109%	N/A
EEM2 – Exterior lighting retrofits	42,496	N/A	N/A	42,496	N/A	N/A	100%	N/A
Total	75,838	N/A	N/A	78,762	N/A	N/A	104%	N/A

* kWh=kilowatt-hours
Source: DNV KEMA analysis

Ex post savings for EEM1 are based on the verified size of the lamps replaced (70 – 400 W) and the size of the lamps installed (36.3 – 124.1 W). An ex ante savings analysis was not provided.

Ex post savings for EEM2 are based on the verified wattage of the pre-retrofit fixtures and the postretrofit fixtures. The operating hours of the various fixtures in this measure were also verified by the evaluation team. An ex ante savings of 7,210 kWh was provided; however, the contractor's revised report expanded the scope of the measure. A revised ex ante savings was not provided, so no realization rate was calculated. The expanded scope included 48 line-item lighting measures of which 17 have been completed. Only the completed installations were used in the ex post savings calculation.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full effective useful life (EUL) of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the remaining useful life (RUL) of the pre-existing equipment has been exceeded.

For the lighting fixture retrofit, the baselines are identical. For the exterior and interior lighting retrofits, The California Database for Energy Efficient Resources (DEER) provides an EUL of 15 years.

Table 161: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline 1&2	1,181,430	N/A	N/A

Source: DNV KEMA analysis

Project Description

This project involved replacing streetlights throughout the city as well retrofitting exterior and interior lighting at seven city facilities including the city council chambers, police station, water plant, wastewater treatment plant (WWTP), and three parks.

Measure 1 – LED Streetlights

EEM1 replaced 65 HPS and two mercury vapor (MV) fixtures with 67 LED fixtures.

Measure 2 – Retrofit Exterior & Interior Light Fixtures

EEM2 retrofitted 56 HPS and three metal halide (MH) wallpack fixtures with induction lamps and drivers. In addition, 15 4-foot T12 fixtures were retrofitted with reduced wattage T8 lamps (28 W) and ballasts and two incandescent exit signs were replaced with LED exit signs.

Savings were calculated using the following algorithm:

$$Annual\ savings\ (kWh) = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Pre-retrofit annual hours of operation for usage group

PostRunHrs = Postretrofit annual hours of operation for usage group (assumed to be the same, as no changes were made to the lighting controls)

Project Evaluation

The evaluation team visited the city on May 1, 2012, to verify the installation of each measure and the hours of operation with site staff and to ensure that the equipment specification met those listed in the program documentation.

Measure 1 – LED Streetlights

A map provided by city staff was used to inspect a sample of streetlights as they were spread throughout the city. The baseline lamp wattages listed on the contractor report were confirmed.

Measure 2 – Retrofit Exterior & Interior Light Fixtures

The contractor report was used to verify all of the line items of this measure. The evaluation team verified the operating hours with site staff and confirmed that the baseline lighting wattages matched the contractor report.

Figure 56: Fixture Close-up

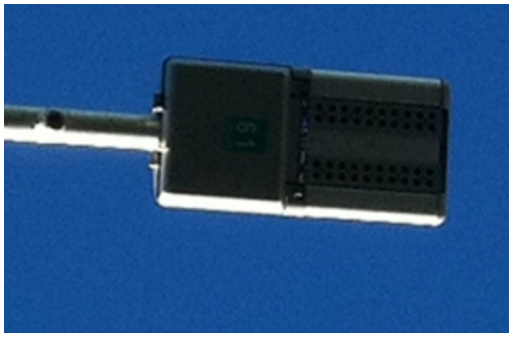


Photo Credit: DNV KEMA

Figure 57: Police Station Induction Wallpack

Photo Credit: DNV KEMA

Figure 58: Exterior Florescent Fixture

Photo Credit: DNV KEMA

Figure 59: Interior Florescent Fixture

Photo Credit: DNV KEMA

Figure 60: LED Exit Sign

Photo Credit: DNV KEMA

Savings Results

The sum of the ex post savings calculation for both measures resulted in 78,762 kWh in annual energy savings. A breakdown of savings for each measure is presented in Table 162 at the beginning of this report. The ex ante savings estimate for the streetlight measure is also

provided as a point of reference. The ex ante savings estimate given for the induction and fluorescent retrofit measures is not applicable to the revised scope of work.

Discussion

Measure 1 – LED Streetlights

On-site verification activities confirmed that a sample of the LED streetlight measure was installed as detailed in the program documentation. Site staff verified the baseline and replacement wattages as detailed in the contractor report. The contractor report used operating hours of 4,100 hours per year. The operating hours used for the ex post savings calculation were 4,380 hours per year, as required by the Measurement and Verification (M&V) guidelines.

Measure 2 – Retrofit Exterior & Interior Light Fixtures

The contractor report indicates that 48 line-item lighting measures were planned in the revised scope. The evaluation team verified that 17 of these measures had been completed. Neither an ex ante savings estimate or analysis was provided for the revised scope, so no realization rate was calculated. The ex post savings calculation includes only the 17 completed line items. The evaluation team was unable to confirm if or when the remaining items will be installed.

The operating hours of each building were confirmed by site staff. The exterior fluorescent lighting at the Christmas Tree Park gazebo are on a timer and are set to run six hours per day, 365 days per year. The exterior fluorescent lighting at Father Stevens Wyatt Park is on 10 hours per week. The city council chambers are occupied for 15 hours per week, and the file storage room at the council chambers is occupied for one hour per week. The evaluation team calculated the savings using the verified lighting counts and operating hours.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1). The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the energy efficiency measure implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 162 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 162: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	78,762	N/A	N/A
2	2013	78,762	N/A	N/A
3	2014	78,762	N/A	N/A
4	2015	78,762	N/A	N/A
5	2016	78,762	N/A	N/A
6	2017	78,762	N/A	N/A

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
7	2018	78,762	N/A	N/A
8	2019	78,762	N/A	N/A
9	2020	78,762	N/A	N/A
10	2021	78,762	N/A	N/A
11	2022	78,762	N/A	N/A
12	2023	78,762	N/A	N/A
13	2024	78,762	N/A	N/A
14	2025	78,762	N/A	N/A
15	2026	78,762	N/A	N/A
Total		1,181,430	N/A	N/A

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

San Joaquin Valley Unified Air Pollution Control District (#71), Riverbank 400W MH to LED Replacement (CBG-09-135-I)

Site Summary

This project involved replacing 269 MH interior fixtures with LED fixtures and 114 occupancy sensor controls with dimming technology in a combined warehouse and industrial building. The lighting retrofits were performed in two phases with phase one consisting of 155 retrofitted fixtures with 81 fixtures receiving occupancy control retrofits and phase two consisting of 114 retrofitted fixtures with 33 fixtures receiving occupancy control retrofits. The evaluation team evaluated only the phase 1 retrofit, which completed at the time of the evaluation. The building is subdivided into smaller spaces that are leased.

Spreadsheet analysis was used to estimate energy savings for the 155 fixtures using a combination of site findings and literature review. The analysis yielded an overall annual electric energy savings of 48.9 percent when compared to ex ante estimates, due to differences in the operating hours and controls. The energy and gas savings by measure are provided in Table 163.

Table 163: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh*)	Maximum Demand Reduction (kW)	Gas Energy (Therms)	Electric Energy (kWh*)	Maximum Demand Reduction (kW)	Gas Energy (Therms)	Electric	Gas
Interior LED lighting	237,811	N/A	0.0	116,394	48.2	0.0	48.9%	N/A
Total	237,811	N/A	0.0	116,394	48.2	0.0	48.9%	N/A

* kWh=kilowatt-hours
Source: DNV KEMA analysis

Ex post savings are based on the verified size of lamp replaced (400 W) and the size of lamp installed (147 W). During the evaluation, the evaluator noted that only 75 of the 155 fixtures were in tenant-occupied spaces. The remaining 80 fixtures were in spaces without tenants. Savings are included for both spaces assuming that the area will be occupied.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures

- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For the lighting fixture retrofit, the baselines are identical. For the indoor lighting retrofits, DEER provides an EUL of 15 years. The overall results from Table 164 yield a life-cycle energy savings of 1, 457,909 kWh and life-cycle demand savings of 723.1 kW-years when considering Baseline 1 and Baseline 2 conditions, as shown in Table 164.

Table 164: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1&2	1,745,910	723.0	0.0

Source: DNV KEMA analysis

Project Description

This project involved the replacement of 155 MH fixtures in a mixed-use warehouse/industrial space. MH fixtures were replaced with LED fixtures.

Savings were calculated using the following algorithm:

$$Annual\ savings\ (kWh) = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Preretrofit annual hours of operation for usage group
PostRunHrs	= Postretrofit annual hours of operation for usage group

Project Evaluation

The evaluation team visited the city on May 4, 2012, to verify with site staff the installation of each measure and the hours of operation and ensure that the equipment specifications met those listed in the program documentation. The evaluation team verified that all of the fixtures had been installed according to the revised scope of work. The team also confirmed that the baseline fixture wattage matched the project documentation with site personnel.

Savings Results

The project saved 116,394 kWh of electric energy and reduced summer on-peak demand by 48.2 kW in the first year when considering Baseline 1 conditions.

Discussion

On-site verification activities confirmed that all of the fixtures were installed as detailed in the program documentation. The site contact confirmed the wattages of the pre-retrofit lighting fixtures and that they were replaced with the LED wattages as described in the contractor invoice. Of the 155 fixtures installed, 75 were operating in tenant-occupied spaces at the time of the evaluation. The remaining 80 fixtures were in tenant-unoccupied spaces.

The site contact indicated that the hours of occupancy of the facility are 10 hours per day, five days a week, for a total of 2,600 hours per year. Postretrofit, 81 fixtures have occupancy sensors that dim the LEDs to half-power when unoccupied. The on-site staff indicated 30 of the 81 occupancy controlled fixtures are not turned off during the hours the facility is unoccupied. The ex ante calculation assumed that the fixtures were turned off completely when the facility was unoccupied; this is the source of the difference between the ex ante and ex post calculation. Annual occupied hours were reduced by 30 percent reduction for occupancy sensor controlled fixtures , based on default savings estimation from the Northeast Energy Efficiency Partnerships (NEEP) *Mid-Atlantic Technical Reference Manual Version 2.0.*[35] During the site visit the evaluation team verified the occupancy sensor controls are operating correctly.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1). The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the energy efficiency measure implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 165 displays the first year savings used to calculate the Baseline 1 and Baseline 2 life-cycle savings. Table 165 also lists the effective and remaining useful lives of each measure. Table 166 presents the electrical energy, electrical demand, and natural gas energy savings for each year the measure is in place up to the end of the measure's EUL.

35 http://neep.org/uploads/EMV%20Forum/EMV%20Products/A5_Mid_Atlantic_TRM_V2_FINAL.pdf.

Table 165: Values Used in Ex Post Life-cycle Savings Calculations

Measure	Early Replacement			Expected Replacement			EUL (years)	RUL (years)
	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)		
Interior LED lighting	116,394	48.2	0.0	116,394	48.2	0.0	15	0
Total	116,394	48.2	0.0	116,394	48.2	0.0	-	-

Source: DNV KEMA analysis

Table 166: Baseline 1 & 2 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW-years)	Natural Gas Energy Savings (Therms/yr)
1	2012	116,394	48.2	0.0
2	2013	116,394	48.2	0.0
3	2014	116,394	48.2	0.0
4	2015	116,394	48.2	0.0
5	2016	116,394	48.2	0.0
6	2017	116,394	48.2	0.0
7	2018	116,394	48.2	0.0
8	2019	116,394	48.2	0.0
9	2020	116,394	48.2	0.0
10	2021	116,394	48.2	0.0
11	2022	116,394	48.2	0.0
12	2023	116,394	48.2	0.0
13	2024	116,394	48.2	0.0
14	2025	116,394	48.2	0.0
15	2026	116,394	48.2	0.0
Life-cycle Total		1,745,910 kWh	723.0 kW-years	0.0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

San Joaquin Air Pollution Control District (CBG-09-136-A), Chowchilla Streetlight Replacement

Site Summary

This project involved replacing 159 HPS streetlight fixtures with LED fixtures throughout the city of Chowchilla.

Table 167: Energy Savings Summary

Measure			Ex Ante		Ex Post		Realization Rate	
Electric Energy (kWh)	Demand (kW)		Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
LED streetlight	86,814	N/A	N/A	71,150	N/A	N/A	82%	N/A
Total	86,814	N/A	N/A	70,150	N/A	N/A	82%	N/A

Source: DNV KEMA analysis

Ex post savings are based on the verified size of lamp replaced (100–250 W) and the size of lamp installed (36.3–175.2 W). Ex ante savings analysis was not provided, but it is presented as being based on a variety of possible lamps sizes being replaced (70–250 W replaced by 20–90 W lamps).

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For the lighting fixture retrofit, the baselines are identical. For the outdoor lighting retrofits, DEER provides an EUL of 15 years.

Table 168: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline 1&2	1,067,250	N/A	N/A

Source: DNV KEMA analysis

Project Description

This project involved the replacement of 159 streetlight fixtures throughout the city of Chowchilla. HPS fixtures were replaced with LED fixtures using the existing poles.

Savings were calculated using the following algorithm:

$$\textit{Annual savings (kWh)} = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Preretrofit annual hours of operation for usage group, 4,380 hours/year for ex post analysis
PostRunHrs	= Postretrofit annual hours of operation for usage group (assumed to be the same, as no changes were made to the lighting controls)

Project Evaluation

The evaluation team visited the city on May 3, 2012, to verify with site staff the installation of each measure and the hours of operation and ensure that the equipment specifications met those listed in the program documentation. The evaluation team verified a sample of fixtures. The team also confirmed that the baseline fixture wattage matched the project documentation with site personal.

Figure 61 and Figure 62 show sample light fixtures surveyed as part of the inspection process.

Figure 61: LED Fixture Close-up

Photo Credit: DNV KEMA

Figure 62: LED Fixture

Photo Credit: DNV KEMA analysis

Savings Results

The ex post savings calculation resulted in 71,150 kWh in annual energy savings.

Discussion

On-site verification activities confirmed that a sample of the lighting measure was installed as detailed in the program documentation. A list of streets with the number of lights on each street was provided by an administrative assistant from the city. From this list, a sample of streets was selected for verification. The site contact confirmed the wattages of the pre-retrofit lighting fixtures and that they were replaced with LED wattages as described in the contractor report.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1). The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the EEM implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 169 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 169: Life-cycle Savings

Life-cycle Savings	Year	Electric Energy Savings (kWh/yr)	Demand Reduction (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	71,150	N/A	N/A
2	2013	71,150	N/A	N/A
3	2014	71,150	N/A	N/A
4	2015	71,150	N/A	N/A
5	2016	71,150	N/A	N/A
6	2017	71,150	N/A	N/A
7	2018	71,150	N/A	N/A
8	2019	71,150	N/A	N/A
9	2020	71,150	N/A	N/A
10	2021	71,150	N/A	N/A
11	2022	71,150	N/A	N/A
12	2023	71,150	N/A	N/A
13	2024	71,150	N/A	N/A
14	2025	71,150	N/A	N/A
15	2026	71,150	N/A	N/A
Total		1,067,250	N/A	

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

San Joaquin Valley Unified Air Pollution Control District (#72), Dos Palos HVAC Replacement and Lighting Retrofit (CBG-09-136-C)

Site Summary

This project involved retrofitting exterior HPS wallpack fixtures with induction fixtures at Dos Palos City Hall. Lighting measures installed also included interior F40T12 lighting fixtures at the police station and WWTP that were retrofitted with F32T8 lamps and ballasts. In addition, HPS streetlight fixtures were retrofitted with LED fixtures throughout the city. The HVAC measure consisted of replacing a 10-ton packaged unit with a new 10-ton unit.

Table 170: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand Reduction (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand Reduction (kW)	Gas Energy (Therms)	Electric	Gas
Interior/Exterior Lighting Retrofit	3,400	N/A	N/A	3,547	1.2	N/A	104.3%	N/A
LED Streetlight	3,863	N/A	N/A	3,508	N/A	N/A	90.8%	N/A
HVAC Replacement	10,180	N/A	N/A	4,722	6.8	N/A	46.4%	N/A
Total	17,443	0.0	0.0	11,777	8.0	0.0	67.5%	N/A

Source: DNV KEMA analysis

The original scope of work for the interior and exterior lighting measures included more than 94 fixtures and was estimated to save close to 19,000 kWh. The scope was later reduced to 41 fixtures. The lighting retrofit saving values in Table 170 reflect the revised scope that shows lower ex ante savings.

For the HVAC replacement, the ex post savings are lower than the ex ante savings estimate. The ex post savings are based on data collected during the site survey and estimated using a weather bin analysis spreadsheet. The analysis for the ex ante savings estimate was not provided; therefore, it is not possible to determine the source of the differences. Natural gas savings were not evaluated since no ex ante therm savings estimates were provided.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures

- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For the lighting measures, the two baselines are identical. For the interior and exterior lighting retrofits, DEER provides an EUL of 15 years. For the HVAC replacement, Baseline 1 savings are based on the estimated efficiency of the HVAC unit replaced and Baseline 2 assumes HVAC unit efficiency based on Title-24-2008 minimum requirements. For HVAC equipment, DEER provides an EUL of 15 years. The life-cycle savings summary can be found in Table 171.

Table 171: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)
Baseline 1	176,655	120.3
Baseline 2	120,934	105.3

Source: DNV KEMA analysis

Project Description

This project includes three measures. The first measure involves retrofitting interior linear fluorescent fixtures and exterior HPS fixtures with energy efficient alternatives. The EEM2 consists of replacing HPS streetlight fixtures with LED fixtures. The third measure replaced HVAC units with new, efficient units.

EEM1 – Interior and Exterior lighting retrofits

This measure consisted of retrofitting 25 F40T12 interior fixtures with F32T8 lamps and ballasts: 23 two-lamp fixtures were retrofitted at the WWTP, two four-lamp fixtures at the council chambers, and an additional three exterior wallpack fixtures with HPS lamps were retrofitted with induction equipment outside the city hall.

EEM2 – LED Streetlights

This measure consisted of replacing the HPS fixtures in 13 streetlights with LED fixtures throughout the city.

Savings for EEM1 and EEM2 were calculated using the following algorithm:

$$Annual\ savings\ (kWh) = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW = Baseline fixture wattage (kW)

BFQ = Baseline fixture quantity (#)

RFW = Retrofit fixture wattage (kW)

RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Preretrofit annual hours of operation for usage group, 4,380 hours/year for ex post analysis
PostRunHrs	= Postretrofit annual hours of operation for usage group (assumed to be the same, as no changes were made to the lighting controls)

EEM3 – HVAC Replacement

This measure replaced one 10-ton packaged air-conditioning unit at city hall with a unit of equal capacity and an EER of 12.2.

Project Evaluation

The evaluation team visited the city on May 16, 2012, to verify the installation of the each measure. The site contact was available to guide the team on a tour of the sites included in each measure. The site contact provided operating hours for the buildings in question as well as for the exterior wallpack fixtures and streetlights.

Figure 63 shows sample light fixtures surveyed as part of the inspection process.

Figure 63: LED Fixture Close Up

Photo Credit: DNV KEMA

Figure 64: Two-lamp F32T8 Fixture at the WWTP

Photo Credit : DNV KEMA

Figure 65: 10-ton Air-conditioning Unit

Photo Credit: DNV KEMA

Savings Results

The ex post savings calculation resulted 11,776 kWh in annual energy savings and a demand savings of 8.8 kW under Baseline 1 conditions. This ex post annual energy savings represents a realization rate of 67.5 percent when compared to ex ante estimates.

Discussion

An analysis of the three measures was conducted based on the provided documentation and information gathered during the site visit.

EEM1 – Interior and Exterior Lighting Retrofits

The reported savings estimate included quantities for interior and exterior fixtures. The police station originally included 37 one-lamp F40T12 fixtures and 4 four-lamp F40T12 fixtures that were to be retrofitted with F32T8 lamps and ballasts. An interview with the site contact revealed that these fixtures were retrofitted before the grant money had been accepted and were removed from the scope of this measure. In addition, two four-lamp F40T12 fixtures were verified by the team. These were the only fixtures included in the ex post savings calculation for the police station using the operating hours provided by the site contact.

The reported scope for the WWTP included eight exterior HPS fixtures that were to be retrofitted with induction equipment in addition to 24 two-lamp F40T12 fixtures and two four-lamp F40T12 fixtures that were to be retrofitted with F32T8 lamps and ballasts. Twenty-three two-lamp fixtures had been retrofitted and the 24th fixture could not be located and its existence was not known to the site contact. The ex post savings calculation included twenty-three fixtures. None of the HPS fixtures had been retrofitted and are not included in the ex post savings calculation.

The reported scope for city hall included three HPS wallpack fixtures, which were verified as installed. They are controlled by photo sensors.

EEM2 – LED Streetlights

The reported scope of this measure was 11 fixtures. During the site visit, 13 fixtures were counted and the contact confirmed that two fixtures were added to the scope. Thirteen fixtures were used for the ex post savings calculations. The site contact confirmed the pre-retrofit fixture wattages and stated that the streetlights are controlled by photo sensors.

EEM3 – HVAC Replacement

The evaluation team verified the make, model, and size of the HVAC unit installed from the unit's nameplate. Site staff estimated the unit replaced was as old as the building, which is 1960s vintage, making the unit at least 40 years old. The staff members were unable to provide any assessment of replaced unit's operational performance, but they did indicate it was operational. The HVAC operating hours used in the weather bin analysis are based on the building's occupancy schedule, which is 8 a.m. to 5 p.m., Monday through Friday. The evaluators added two hours to the beginning and ending of each day to make the daily operating hours 6 a.m. to 7 p.m. A 10 percent degradation factor is included for the old units.

Ex Post Life-cycle Savings

Life-cycle energy savings were calculated relative to both Baseline 1 and Baseline 2.

Table 172 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 172: Life-cycle Savings

		Baseline 1		Baseline 2	
Life-cycle Year	Calendar Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW-years)	Electric Energy Savings (kWh/yr)	Electrical Demand (kW-years)
1	2012	11,777	8.0	11,776	8.0
2	2013	11,777	8.0	7,797	6.9
3	2014	11,777	8.0	7,797	6.9
4	2015	11,777	8.0	7,797	6.9
5	2016	11,777	8.0	7,797	6.9
6	2017	11,777	8.0	7,797	6.9
7	2018	11,777	8.0	7,797	6.9
8	2019	11,777	8.0	7,797	6.9
9	2020	11,777	8.0	7,797	6.9
10	2021	11,777	8.0	7,797	6.9
11	2022	11,777	8.0	7,797	6.9
12	2023	11,777	8.0	7,797	6.9
13	2024	11,777	8.0	7,797	6.9
14	2025	11,777	8.0	7,797	6.9
15	2026	11,777	8.0	7,797	6.9
Life-cycle Total		176,655 kWh	120.0 kW-years	120,934 kWh	104.6 kW-years

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

San Joaquin Valley Unified Air Pollution Control District (#71), City of Exeter Retrofits (CBG-09-136-D)

Site Summary

This project involved the retrofit of T12 fixtures with high performance T8 lamps and ballasts at the City of Exeter police station. The project also included retrofitting HVAC package units and split systems at the police station, city hall, and high school in Exeter.

Table 173 summarizes the ex ante and ex post savings estimates for this project.

Table 173: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
T12 fluorescent to T8 fluorescent	8,310	N/A	N/A	24,181	5.5	0.0	291%	N/A
HVAC	51,918	N/A	N/A	23,669	30.1	183	46%	N/A
Total	60,228[36]	N/A	N/A	47,850	35.6	183	79%	N/A

Source: DNV KEMA analysis

The high realization rate for the lighting measure is due to an increased number of installed fixtures (81 reported initially with savings of 11,073 versus 101 installed) and the hours of operation being underestimated in the ex ante savings analysis. Typical office operating hours were estimated; however, the evaluation team determined that the police station typically operates more than one shift per day. The savings reported in the September 28, 2012 database indicated lower savings of 8310 kWh. The savings in the database are listed here.

No analysis was provided for the ex ante HVAC energy savings estimate. According to the September 28, 2012 database, two 3-ton and four 3-ton units were replaced for a total savings of 56,918 kWh. The previous data provided indicated four each of 2.5 and 3-ton units, with total HVAC savings of 15,810. Fifty-one tons of HVAC equipment were observed as installed.

36 The original site report submitted to the CEC included an HVAC measure with estimated electric savings of 5,000 kWh. DNV KEMA did not evaluate this measure as part of the sample, thus it is not included here; it is included as part of the overall estimated program savings.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

An EUL of 15 years is used for all measures.

Table 174: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction(kW)	Natural Gas Energy Savings (Therms)
Baseline 1	717,750	35.6	2,745
Baseline 2	391,745	5.8	2,745

Source: DNV KEMA analysis

Project Description

This project involved the retrofitting T12 light fixtures with high performance T8 lamps and ballasts. The project also included retrofitting HVAC package units and split systems at the police station, city hall, and high school.

The lighting retrofit consists of 101 measures, including T12 to HPT8 lamp and ballast retrofits, and occupancy sensors.

The HVAC project consisted of replacing one 5-ton and one 3-ton split system at the city hall. One 5-ton package HVAC unit, one 3-ton package HVAC unit, and one 5-ton split system were replaced at the police station. The high school also had six 5-ton package HVAC units and one 3-ton HVAC package unit replaced.

Project Evaluation

The evaluation team visited the facility on May 17, 2012, to verify the installation and operation of the lighting and HVAC measures.

Measure 1 – Lighting Retrofit

The evaluation team surveyed the police station and inspected the majority of lighting fixtures were retrofitted. Site staff confirmed the police station's operating hours. No discrepancies were found between the inspected lighting fixtures and those reported in the project's ex ante savings documentation. The hours of operations were increased because conversation with the police staff indicated that the police station operated more than one shift a day.

Due to the increased light output of the retrofitted lighting, the staff indicated that generally only half of the lamps are turned on at any one time. This suggests the energy savings may be even greater than calculated in the ex post analysis. However, since pre-retrofit operation of the lighting could not be confirmed, the reduced operating hours due to dual-switching was not included in the savings estimate.

Measure 2 – HVAC Retrofit

The evaluation team verified the make, model, and size of the HVAC unit installed from the unit's nameplate and installation invoice for each site. Site staff members estimated that the units that were replaced were 15 to 20 years old. The staff members were unable to provide any assessment of the replaced units' operational performance, but they did indicate that they were operational. The HVAC operating hours used in the weather bin analysis are based on the building's occupancy schedule provided by the site staff. In the analysis, degradation for the age of the equipment was taken into account.

Savings Results

The total annual energy savings for all projects was verified as 45,850 kWh and 2,749 therms. A non-coincident demand reduction of 35.6 kW was also realized.

Ex Post Life-cycle Savings

Energy savings were calculated relative to dual baselines. Baselines 1 and 2 are identical for the lighting measure. The life-cycle analysis is based on an EUL of 15 years.

Table 175: Life-cycle Savings

		Baseline 1			Baseline 2		
Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	47,850	35.6	183	47,850	5.8	183
2	2013	47,850	35.6	183	24,564	5.8	183
3	2014	47,850	35.6	183	24,564	5.8	183
4	2015	47,850	35.6	183	24,564	5.8	183
5	2016	47,850	35.6	183	24,564	5.8	183
6	2017	47,850	35.6	183	24,564	5.8	183
7	2018	47,850	35.6	183	24,564	5.8	183
8	2019	47,850	35.6	183	24,564	5.8	183
9	2020	47,850	35.6	183	24,564	5.8	183
10	2021	47,850	35.6	183	24,564	5.8	183
11	2022	47,850	35.6	183	24,564	5.8	183
12	2023	47,850	35.6	183	24,564	5.8	183
13	2024	47,850	35.6	183	24,564	5.8	183
14	2025	47,850	35.6	183	24,564	5.8	183

		Baseline 1			Baseline 2		
Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
15	2026	47,850	35.6	183	24,564	5.8	183
Total		717,750		2,745	391,746		2,745

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

San Joaquin County Air Pollution Control District (CBG-09-136-F), Fowler Streetlight Replacement

Site Summary

This project involved replacing HPS streetlight fixtures with LED fixtures throughout the city. Table 176 below presents a summary of the energy savings.

Table 176: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
LED streetlights	24,305	N/A	0.0	32,920	N/A	0.0	135%	N/A
Total	24,305	N/A	0.0	32,920	N/A	0.0	135%	N/A

Source: DNV KEMA analysis

Ex post savings are based on the wattage of the fifty replaced fixtures (176 – 348 W) and the wattage of the installed LED fixtures (60 – 124 W) as reported on the contractor's invoice. Total ex ante savings were provided, but no detailed savings analysis was made available. The ex ante savings estimate is based on 38 fixtures, consisting of a variety of possible lamp sizes being replaced. Based on the information available, it is likely the high realization rate is due to the expanded project scope.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For the lighting fixture retrofit, the baselines are identical. For the outdoor lighting retrofits, DEER provides an EUL of 15 years.

Table 177: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline 1 & 2	493,800	N/A	0.0

Source: DNV KEMA analysis

Project Description

The revised project scope indicated that fifty streetlight fixtures would be replaced throughout the city of Fowler. HPS fixtures were replaced with LED fixtures using the existing poles.

Savings were calculated using the following algorithm:

$$\textit{Annual savings (kWh)} = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW = Baseline fixture wattage (kW)

BFQ = Baseline fixture quantity (#)

RFW = Retrofit fixture wattage (kW)

RFQ = Retrofit fixture quantity (#)

BaseRunHrs = Pre-retrofit annual hours of operation for usage group, 4,380 hours/year for ex post analysis, per the evaluation guidelines

PostRunHrs = Postretrofit annual hours of operation for usage group (assumed to be the same, as no changes were made to the lighting controls)

Project Evaluation

The evaluation team visited the city on May 2, 2012, to verify the installation of the streetlights and the hours of operation. The site contact was not available at the time of the survey. However, a map with streetlight locations was provided.

Figure 66 shows sample light fixtures surveyed as part of the inspection process.

Figure 66: LED Fixture Close-Up

Photo Credit DNV KEMA

Savings Results

The ex post savings calculation resulted in 32,920 kWh in annual energy savings.

Discussion

The evaluation teams used a streetlight map provided by site staff to locate retrofitted streetlights. Forty-five of the fifty streetlights were located and inspected. The map provided only general locations, and the site contact was not available to assist with locating the remaining streetlights. Given the documentation indicates fifty fixtures were retrofitted and the fixtures inspected were as documented, the ex post savings analysis is based on the contractor's stated quantity of fifty fixtures.

The streetlights were verified as being controlled by photo sensors.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1). The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the energy efficiency measure implementation.

Table 178 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 178: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	32,920	N/A	N/A
2	2013	32,920	N/A	N/A
3	2014	32,920	N/A	N/A
4	2015	32,920	N/A	N/A

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
5	2016	32,920	N/A	N/A
6	2017	32,920	N/A	N/A
7	2018	32,920	N/A	N/A
8	2019	32,920	N/A	N/A
9	2020	32,920	N/A	N/A
10	2021	32,920	N/A	N/A
11	2022	32,920	N/A	N/A
12	2023	32,920	N/A	N/A
13	2024	32,920	N/A	N/A
14	2025	32,920	N/A	N/A
15	2026	32,920	N/A	N/A
Total		493,800		N/A

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

San Joaquin Valley Unified Air Pollution Control District (#72), Sanger Streetlight Replacement (CBG-09-136-T)

Site Summary

This project involved replacing 260 HPS streetlight fixtures with LED fixtures throughout the city. Of the 303 fixtures replaced, 260 were purchased using funding from the EECBG. The remaining were purchased using city funds. Table 179 summarizes the ex post and ex ante savings estimates for this project.

Table 179: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
LED streetlight	67,589	0	0	70,150	0	0	104%	N/A
Total	67,589	0	0.0	70,150	16.0	0.0	104%	N/A

Source: DNV KEMA analysis

The ex post savings are based on verification of the pre (85 W) and post (23.4 W) retrofit streetlight wattages and quantities. The ex ante savings analysis was not provided, but it is presented as being based on a variety of possible lamps sizes being replaced (70–400 W replaced by 20–120 W lamps). The ex ante savings listed were provided in the tracking data updated in September 2012. The reason for the realization rate is the ex post analysis assumes 4380 hours per year operation, rather than 4100 hours per year.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For both lighting fixture retrofits, the baselines are identical. For the outdoor lighting retrofits, the industry standard is an EUL of 15 years.

Table 180: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline 1&2	1,052,250	16.0	0.0

Source: DNV KEMA analysis

Project Description

This project involved the replacement of 260 streetlight fixtures throughout the city of Sanger. HPS fixtures were replaced with LED fixtures using the existing poles.

Savings were calculated using the following algorithm:

$$Annual\ savings\ (kWh) = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Preretrofit annual hours of operation for usage group, 4,380 hours/year for ex post analysis
PostRunHrs	= Postretrofit annual hours of operation for usage group (assumed to be the same as no changes were made to the lighting controls)

Project Evaluation

The evaluation team visited the city on May 2, 2012, to verify with site staff the installation of each measure and the hours of operation and ensure that the equipment specifications met those listed in the program documentation. The evaluation team verified that 260 fixtures had been replaced, and they confirmed that the baseline fixture wattage matched the project documentation.

Figure 67 and Figure 68 below show sample light fixtures surveyed as part of the inspection process.

Figure 67: LED Fixture Close-up

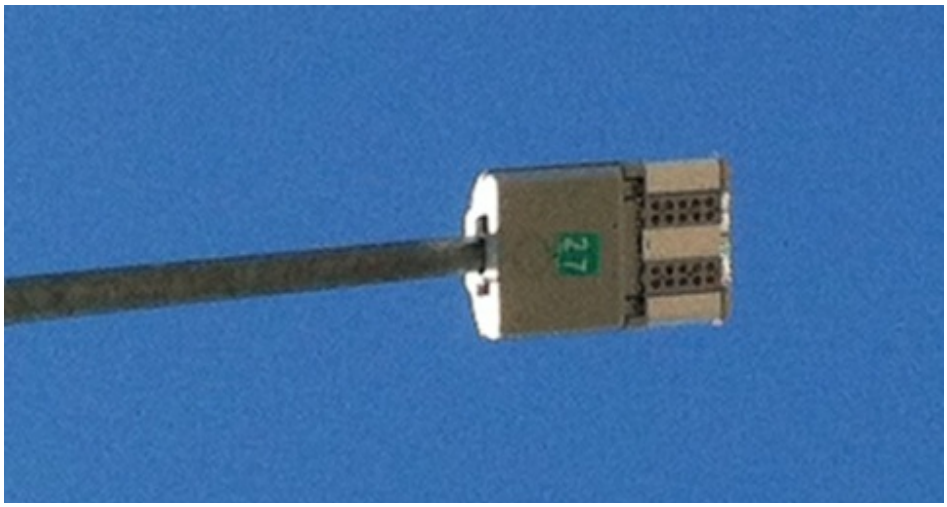


Photo Credit: DNV KEMA

Figure 68: LED Fixture

Photo Credit: DNV KEMA

Savings Results

The ex post savings calculation resulted in 70,150 kWh in annual energy savings. Demand savings of 16.0 kW were also realized.

Discussion

On-site verification activities confirmed that the lighting measure was installed as detailed in the program documentation. A map locating the replaced streetlights was provided by the site contact. This map was used to make visual confirmation that 260 lights had been installed. CBG funds were used to install 260 fixtures, while the others were funded separately by the City of Sanger. The site contact and contractor report confirmed that all of the pre-retrofit lighting fixtures used 85 watts and were replaced with 23.4 watt LEDs.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1). The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the EEM implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 181 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 181: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	70,150	16.0	0.0
2	2013	70,150	16.0	0.0
3	2014	70,150	16.0	0.0
4	2015	70,150	16.0	0.0
5	2016	70,150	16.0	0.0
6	2017	70,150	16.0	0.0
7	2018	70,150	16.0	0.0
8	2019	70,150	16.0	0.0
9	2020	70,150	16.0	0.0
10	2021	70,150	16.0	0.0
11	2022	70,150	16.0	0.0
12	2023	70,150	16.0	0.0
13	2024	70,150	16.0	0.0
14	2025	70,150	16.0	0.0
15	2026	70,150	16.0	0.0
Total		1,052,250 kWh		0.0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

San Joaquin Air Pollution Control District (CBG-09-136-U), Shafter LED Streetlight and Well Pump Replacement

Site Summary

This project involved replacing HPS streetlight fixtures with LED streetlight fixtures throughout the city. In addition, a well pump motor was replaced with a new, premium efficiency motor. Table 182 summarizes the ex ante and ex post savings.

Table 182: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 LED streetlight	42,538	N/A	N/A	31,507	N/A	N/A	74%	N/A
EEM2 Premium efficiency motor	14,775	N/A	N/A	5,847	2.5	N/A	40%	N/A
Total	57,313	N/A	N/A	37,354	2.5	N/A	65%	N/A

Source: DNV KEMA analysis

For the streetlight retrofit, the reported ex ante savings estimate was based on a project scope of 76 fixtures, with estimated savings of 48,160 kWh. The contractor's invoice indicates that the scope was increased to include 136 fixtures. No savings estimate was provided for the revised scope of work; therefore, the realization rate was not calculated.

For the new motor retrofit, the reported ex ante savings estimate (126,195 kWh) was based on installing a variable frequency drive (VFD). However, no VFD was installed. Instead, a new National Electrical Manufacturers Association (NEMA) Premium efficiency motor was installed. No savings estimate was provided for the motor replacement; therefore, no realization rate was calculated.

Ex post savings for this measure are based on the replacement of a 150 horsepower (hp) pump motor with a NEMA Premium efficiency 150 hp motor using the operating hours provided by site staff.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures

- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For the lighting fixture retrofit, the baselines are identical. For the outdoor lighting retrofits, DEER provides an EUL of 15 years. For the motor, the baselines are identical. DEER also provides an EUL of 15 years for new motors.

Table 183: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline 1 & 2	560,310	37.5	N/A

Source: DNV KEMA analysis

Project Description

This project consisted of two measures.

EEM1 – LED Streetlights

This measure replaced 112 HPS streetlight fixtures in the city of Shafter with LED streetlight fixtures.

Savings were calculated using the following algorithm:

$$Annual\ savings\ (kWh) = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Pre-retrofit annual hours of operation for usage group, 4,380 hours/year for ex post analysis
PostRunHrs	= Postretrofit annual hours of operation for usage group (assumed to be the same, as no changes were made to the lighting controls)

EEM2 – Premium Efficiency Motor

This measure replaced a 150 hp pump motor with a new, NEMA Premium efficiency motor while retaining the original pump.

Project Evaluation

The evaluation team visited the city on May 18, 2012, to verify the installation of the streetlights and well pump motor and to interview the site staff regarding the operation of each system.

Figure 69 shows a sample light fixture surveyed as part of the inspection process. Figure 70 shows the well pump motor as installed.

Figure 69: LED Fixture Close-Up

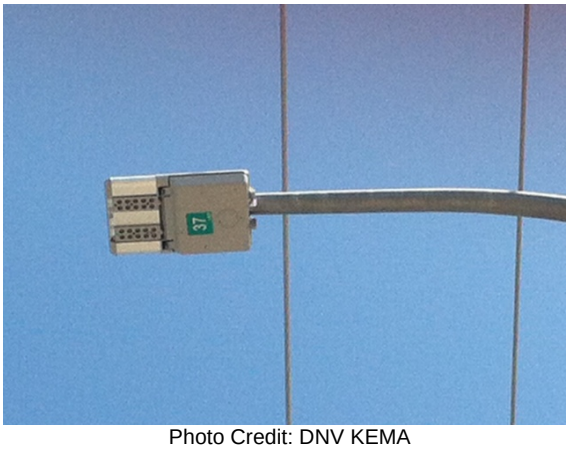


Photo Credit: DNV KEMA

Figure 70: Well Pump Motor

Photo Credit: DNV KEMA

Savings Results

The ex post savings calculation resulted in 37,354 kWh in annual energy savings. Demand savings of 2.5 kW were also realized.

Discussion

An analysis of the three measures was conducted based on the provided documentation and information gathered during the site visit.

EEM1 – LED Streetlights

On-site verification confirmed that 112 LED streetlights fixtures had been installed. The evaluation team was provided with a map of the city's streetlights. Photo sensors were confirmed to be used for on/off control of the streetlights.

EEM2 – Premium Efficiency Motor

On-site verification of the well pump motor confirmed the rated horsepower of 150 hp and that it was a NEMA Premium efficiency motor. The team also spot measured the motor while it was running. The measurements showed it was running at 123 kW, or 165 hp at a load factor of 110.1 percent. The site contact provided the operating hours of the pump stating that it runs approximately 10 hours per day every day during the peak season, which is from the beginning of June to the end of July. During the off-peak season, it runs approximately five hours per day, every day. Total operating hours were calculated to be 2,100 hours per year.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1). The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the energy efficiency measure implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 184 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 184: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Demand Reduction (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	37,354	2.5	N/A
2	2013	37,354	2.5	
3	2014	37,354	2.5	
4	2015	37,354	2.5	
5	2016	37,354	2.5	
6	2017	37,354	2.5	
7	2018	37,354	2.5	
8	2019	37,354	2.5	
9	2020	37,354	2.5	
10	2021	37,354	2.5	
11	2022	37,354	2.5	
12	2023	37,354	2.5	
13	2024	37,354	2.5	

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Demand Reduction (kW)	Natural Gas Energy Savings (Therms/yr)
14	2025	37,354	2.5	
15	2026	37,354	2.5	
Total		560,310	37.5	

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Barstow, City of(CBG-09-137)

Site Summary

The City of Barstow conducted lighting retrofits at a total of seven buildings, including the Police Department, City Hall, Police Annex, Water Reclamation Plant, Corporation City Yard, and the Harper Fitness Center. The comprehensive lighting retrofits included installing new fixtures and/or new bulbs and 3 vending misers. All of the buildings underwent lighting retrofits of many of the interior and exterior lighting fixtures.

The bulk of the retrofits consisted of replacing old T12 and T8 fixtures with new low wattage T8 fixtures, replacing older ballasts with new more efficiency ballasts, installing new occupancy sensors where applicable, and delamping. In total, 725 lighting fixtures were retrofitted with 659 fixtures.

Ex ante and ex post savings for the lighting retrofit are provided in Table 185 below. Ex ante savings were collected from the Energy Commission and were corroborated by the savings listed in the implementer's ex ante analysis. Ex post savings were calculated from data provided in project files and from data collected during the on-site verification. The collected data was analyzed to yield an overall electric energy savings of 101 percent when compared to the estimated ex ante savings.

Lighting retrofits took place in the Barstow Police Department, City Hall, Police Annex, Water Reclamation Plant, Corporation City Yard, and the Harper Fitness Center. The Police Department is occupied 24 hours per day, 7 days per week, 365 days per year, while the other buildings operate on independent building schedules. The Police Annex is separate from the Police Department building and is not occupied 24/7. The Police Department, Police Annex, and Wastewater Plant have zero annual holidays, while the other buildings have eight annual holidays.

Total annual savings is 183,101 kWh, with a realization rate of 108 percent.

Table 185: Energy Savings Summary

Building	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
CFLs (Interior)	4,507	Not Reported	0	5,256	1.4	0	117%	N/A
CFLs (Exterior)	13,271	Not Reported	0	14,420	2.8	0	109%	N/A

Building	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
Induction Fixtures (Exterior)	4,030	Not Reported	0	4,030	0.9	0	100%	N/A
LED Exit Signs	986	Not Reported	0	986	0.1	0	100%	N/A
New CFL Fixtures	24	Not Reported	0	24	0.0	0	100%	N/A
New Fixtures T12 to T8	45,805	Not Reported	0	41,657	15.0	0	91%	N/A
T12 to T8 Retrofits	47,604	Not Reported	0	61,489	16.4	0	129%	N/A
T8 to T8 Retrofits	2,350	Not Reported	0	3,407	1.3	0	145%	N/A
MH to T5 (interior)	47,121	Not Reported	0	50,710	12.0	0	108%	N/A
Vending Miser	3,366	Not Reported	0	1,122	0.0	0	33%	N/A
Totals	169,064			183,101			108%	

Source: DNV KEMA analysis

The project saved more than the claimed savings in the ex ante analysis primarily because the operating hours used in the ex ante calculations were estimates and differed from the operating hours collected during the site visit. The majority of the installed fixtures were verified during the on-site visit, so the deemed number of fixtures was accepted to be accurate. There were no significant differences in the number of retrofitted fixtures.

Life-cycle savings for the EEMs were calculated on the basis of EUL estimates from the California DEER. The DEER EULs for the interior lighting fixtures was 15 years.

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment is exceeded

It was assumed that the buildings involved in the lighting retrofits were already code compliant, so the Baseline 1 and Baseline 2 savings for this project were the same. Table 186 below summarizes the life-cycle savings relative to each of these baselines.

Table 186: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1	2,746,515	662	0
Baseline 2	2,746,515	662	0

Source: DNV KEMA analysis

Project Description

Many measures were implemented at the various Barstow city facilities. The different measures are explained below.

CFLs (Interior) – This measure retrofitted incandescent bulbs ranging from 60 to 90 watts with compact fluorescent bulbs (CFL) ranging from 15 to 27 watts. In total, 28 bulbs were changed with 23 new bulbs confirmed during the site visit. Not all of the bulbs could be verified because of accessibility issues and time constraints. Since the verified bulbs matched with the documented bulbs, the unverified bulbs were also assumed to be accurately installed. These retrofits occurred in the City Yard (2), Fitness Center (14), Police Department (1), and Wastewater Building (11).

CFLs (Exterior) – This measure retrofitted exterior HPS, MH, and incandescent bulbs ranging from 60 to 464 watts with compact fluorescent bulbs ranging from 15 to 42 watts. In total, 8 bulbs were changed with 8 new bulbs confirmed during the site visit. These retrofits occurred in the City Yard (3), City Hall (1), Fitness Center (2), Police Annex (1), and Wastewater Building (1).

Induction Fixtures (Exterior) – This measure retrofitted exterior pole mounted HPS lights with high output F54T5 fixtures. In total, 4 fixtures were changed with all 4 fixtures confirmed during the site visit. These retrofits occurred in the parking lot of the Police Annex building (4).

LED Exit Signs – This measure retrofitted incandescent exit signs with LED exit signs. The pre-retrofit exit signs were illuminated using two 20 watt incandescent bulbs, while the postretrofit exit signs used two 1.5 watt LEDs. Three exit signs were retrofitted with all three fixtures confirmed during the site visit. These retrofits occurred in the Police Department (3).

New CFL Fixtures – This retrofit changed one 60 watt incandescent bulb into a 15 watt CFL bulb in the custodian closet of the Fitness Center. This was the only fixture for this measure and was confirmed during the on-site visit.

New Fixtures T12 to T8 – This measure retrofitted T12 fixtures ranging from 75 to 216 watts with T8 fixtures ranging from 42 to 84 watts. The majority of the pre-retrofit fixtures were 8 foot F96T12, and the postretrofit fixtures were mainly 8 foot F32T8. Some fixtures were also delamped to further increase the energy savings. In total, 194 fixtures were retrofitted and 91 fixtures were confirmed during the on-site visit. The bulk of the retrofits took place in the Police Department building, which we did not have access to during the site visit. The site contact

confirmed that the unverified fixtures were installed. These retrofits occurred in the City Yard (53), City Hall (109), Police Department (18), Wastewater Plant (12) and Fitness Center (2).

T12 to T8 Retrofits – This measure retrofitted F40T12 fixtures ranging from 78 to 230 watts with F32T8 fixtures ranging from 42 to 84 watts. Additional fixtures were added in some areas to increase lighting output, while still decreasing energy usage. In total, 276 fixtures were retrofitted and 194 fixtures were confirmed during the on-site visit. Not all fixtures were verified due to time constraints and accessibility issues. Since the verified fixtures matched the documented fixtures, the unverified fixtures were also assumed to be accurately installed. These retrofits occurred in the City Hall (87), City Yard (5), Fitness Center (66), Police Annex (49), Police Department)50), and Wastewater Plant (19).

T8 to T8 Retrofits – This measure retrofitted existing T8 fixture ranging from 58 to 110 watts with more efficient T8 fixtures ranging from 42 to 84 watts. Some fixtures were also delamped to further increase the energy savings. In total, 73 fixtures were retrofitted with 69 fixtures confirmed during the on-site visit. Not all fixtures were verified due to time constraints and accessibility issues. Since the verified fixtures matched the documented fixtures, the unverified fixtures were also assumed to be accurately installed. These retrofits occurred in the City Yard (6), City Hall (62), and Wastewater Plant (4).

MH to T5 (Interior) – This measure retrofitted interior T12 and MH fixtures ranging from 138 to 458 watts with high output 234 watt T5 fixtures. These fixtures were usually found in large open areas such as garage bays and gymnasiums. In total, 111 original fixtures were retrofitted with 51 new fixtures that were all confirmed during the site visit. The additional 60 fixtures were removed to further increase the energy savings. These retrofits occurred in the City Yard (6), Fitness Center (38), and Wastewater Plant (7).

Vending Misers – This measure added occupancy sensors to vending machines that reduced their operating hours and thus saved energy. The occupancy sensor kept the vending machine powered off when the nearby area was vacant in order to reduce both cooling and lighting costs. There were a total of three vending misers installed in the City Yard, Police Department, and Senior Center buildings. The vending misers in the City Yard (1) and Senior Center (1) were verified during the site visit, but the Police Department vending miser was not confirmed due to accessibility issues. The Police Department vending miser (1) was confirmed to be installed by the site contact.

Ex Ante Savings

Johnson Controls conducted the ex ante savings analysis using a spreadsheet calculation. In general, for any group of fixtures, savings were calculated as:

$$kWh_{saved} = \frac{n}{1000}(W_{bl}h_{bl} - W_{ins}h_{ins})$$

Where,

n = Number of affected fixtures

W_{bl} = Baseline Fixture Wattage [W]

h_{bl} = Baseline Operating Hours [h]

W_{ins} = Installed Fixture Wattage [W]

h_{ins} = Installed Operating Hours (potentially adjusted for occupancy sensors) [h]

1,000 = [W/kW]

Savings from all affected fixture groups were then summed to estimate gross project savings.

Project Evaluation

A DNV KEMA engineer visited the facilities on January 13, 2012 to verify the installation of fixtures and to gather facility lighting schedules to assist in assessing energy savings. From the 829 newly installed fixtures, a sample of 540 fixtures were identified. The fixtures located in the Police Department were not visually verified because the site contact did not have access to the Police Department building, but he confirmed that the fixtures were installed. Some fixtures in other buildings were not verified due to accessibility issues and time constraints.

Operating hours for each individual building were collected during the site visit and were used in place of the ex ante estimated operating hours. Some individual rooms did not follow the full operating hours of the building, such as the bathrooms and closets, and the calculation used adjusted hours. Exterior fixtures controlled by photocells were assumed to operate for 12 hours per day for a total of 4380 annual operating hours based on average sunrise and sunset times for Barstow, CA. The Police Department operated 24 hours per day for a total of 8760 annual operating hours. Exit signs were also assumed to operate for 8760 annual operating hours.

In order to account for the additional savings due to the installation of occupancy sensors, the operating hours for effected fixtures was scaled by a factor of $\frac{1}{(1-.3)}$, which follows from the standard practice assumption that occupancy sensors yield a 30 percent reduction in lighting time-of-use according to the 2010 NEEP Mid-Atlantic Technical Reference Manual Version 1.1.

Savings with respect to the Energy Commission's pre-existing equipment baseline were calculated using the same general methodology as the ex ante analysis. For a given group of lights, the savings were calculated as:

$$kWh_{saved} = hours\ x\ \frac{n}{1000}(W_{bl}h_{bl} - W_{ins}h_{ins})$$

Where,

hours = Operating Hours

n = Number of affected fixtures

W_{bl} = Baseline Fixture Wattage [W]

h_{bl} = Baseline Operating Hours [h]

W_{ins} = Installed Fixture Wattage [W]

h_{ins} = Installed Operating Hours (potentially adjusted for occupancy sensors) [h]

1,000 = [W/kW]

Savings Results

The project achieved annual energy savings of 183,100 kWh and 44.12 kW in demand savings compared to the ex ante estimate of 181,207 kWh in savings. Table 219 provides a breakdown of the ex post energy savings along with the ex ante energy savings for comparison.

Discussion

The project had different savings than estimated in the ex ante analysis for a few key reasons. First, the estimated operating hours used in the ex ante analysis were different from the building specific operating hours confirmed during the site visit by the site contact. Third, some of the ex post fixture counts did not match the ex ante counts, so the savings were adjusted accordingly.

Ex Post Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

According to the feasibility study for Barstow, the interior lighting for the Barstow Police Department, City Hall, Police Annex, Water Reclamation Plant, Corporation City Yard, and the Harper Fitness Center were all twenty years old, which were all beyond their EUL. Based on the DEER database, the EUL for interior lighting fixtures is 15 years. Table 187 summarizes the energy savings and life-cycle parameters used in the life-cycle savings calculations.

Table 187: Values used in Life-cycle Savings Calculations

Measure	Early Replacement		Expected Replacement		EUL (years)	RUL (years)
	Electric energy (kWh)	Gas Energy (Therms)	Electric energy (kWh)	Gas Energy (Therms)		
CFLs (Interior)	5,256	0	5,256	0	15	1
CFLs (Exterior)	14,420	0	14,420	0	15	1
Induction Fixtures (Exterior)	4,030	0	4,030	0	15	1

Measure	Early Replacement		Expected Replacement		EUL (years)	RUL (years)
	Electric energy (kWh)	Gas Energy (Therms)	Electric energy (kWh)	Gas Energy (Therms)		
LED Exit Signs	986	0	986	0	15	1
New CFL Fixtures	24	0	24	0	15	1
New Fixtures T12 to T8	41,657	0	41,657	0	15	1
T12 to T8 Retrofits	61,489	0	61,489	0	15	1
T8 to T8 Retrofits	3,407	0	3,407	0	15	1
MH to T8 (interior)	50,710	0	50,710	0	15	1
Vending Miser	1,122	0	1,122	0	15	1

Source: DNV KEMA analysis

Table 188 below provides life-cycle savings for the project relative to Baseline 1 on a year-by-year basis through the EUL of the longest lived measure. Under this baseline, energy savings were presumed to occur relative to the pre-existing equipment for the duration of each measure's life. For this project, the life-cycle savings estimates relative to Baseline 2 (dual baseline) are the same as the life-cycle savings relative to Baseline 1.

Table 188: Baseline Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	183,101	48.3	0
2	2012	183,101	48.3	0
3	2013	183,101	48.3	0
4	2014	183,101	48.3	0
5	2015	183,101	48.3	0
6	2016	183,101	48.3	0
7	2017	183,101	48.3	0
8	2018	183,101	48.3	0
9	2019	183,101	48.3	0
10	2020	183,101	48.3	0
11	2021	183,101	48.3	0
12	2022	183,101	48.3	0

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
13	2023	183,101	48.3	0
14	2024	183,101	48.3	0
15	2025	183,101	48.3	0
16	2026	0	0	0
	Total	2,746,515 kWh	725 kW	0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Seal Beach, City of(CBG-09-154)

Site Summary

This project involved the installation of new lamps and ballasts or complete replacement of 633 fixtures throughout two Seal Beach buildings. The following areas were included in the retrofit: City Hall and the Police Department. Typical operating hours for City Hall are 7 a.m. to 6 p.m. Monday through Friday with limited operation on the weekend for cleaning services. The police department operates 24 hours per day.

The implemented measures at Seal Beach buildings included a two-part lighting retrofit for both indoor (EEM1) and outdoor (EEM2) fixtures. In addition, UV light emitters were installed in 24 rooftop HVAC units in the two buildings. Table 189 summarizes the ex post and ex ante savings estimates for this project.

Table 189: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 – Retrofit indoor light fixtures	60,223	None Claimed	0	72,198	2.58	0.0	120%	N/A
EEM2 – Retrofit outdoor light fixtures	39,303	None Claimed	0	36,888	0	0.0	94%	N/A
EEM3 – Install UV Emitter in Rooftop HVAC	25,032	None Claimed	0	N/A	N/A		N/A	

Source: DNV KEMA analysis

For EEM1, EEM2, and EEM3 there was very little included in the ex ante savings estimated. As such, while there were differences between the ex ante and ex post savings results, it is not possible to determine the source of the differences. For EEM1 and EEM2, a sample of fixtures which included all major types and all buildings involved in the project revealed no discrepancies between the installed equipment and the equipment listed on the invoices provided to the evaluation team by the site contact.

For EEM3, the site inspection revealed that UV light emitters were installed as described in the limited program documentation. As stated in the M&V plan, because there were no savings calculations included in the program documentation, the site contacts could not provide savings

calculations and the evaluation timeline did not allow for pre and postinstallation measurement, the evaluation team was not able to verify the calculation methodology for this measure. However, a savings estimate based on-site visit observations and analysis of the HVAC unit's cut-sheets is presented in the project evaluation section below.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For both lighting and HVAC retrofits, the baselines are identical.

For the indoor lighting retrofits (EEM1) and outdoor lighting retrofits (EEM2), DEER provides an EUL of 15 years. DEER does not list an EUL for the UV light emitters, but it lists cleaning condenser coils as a three-year EUL.

Table 190: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline 1 & 2	1,492,890	2.58	0.0

Source: DNV KEMA analysis

Project Description

This project involved the installation of new lamps and ballasts or complete replacement of 633 fixtures throughout two Seal Beach buildings, as well as an HVAC retrofit. The following areas were included in the retrofit: City Hall and Police Department.

Measure 1 – Retrofit Indoor Light Fixtures

EEM1 consisted of a complete lighting retrofit of all fluorescent fixtures in City Hall and the Police Department as well as the installation of new LED and CFL bulbs. A room-by-room lighting survey was not completed for this project. Site contacts provided the evaluation team with a full project invoice that detailed the total number of ballasts, lamps, and bulbs installed as part of this retrofit. Site contacts confirmed that baseline technology for this measure was 32W T8 fixtures with standard ballast-factor ballasts. The site contact also confirmed that LED and CFL fixtures replaced incandescent bulbs.

Annual hours of operation for the two buildings were provided by the site contact. The program documentation did not specify the annual hours of operation and quantity of fixtures used in the original calculations; as such, the evaluation team can't determine where discrepancies in total savings numbers arise from.

Measure 2 – Retrofit Outdoor Light Fixtures

EEM2 consisted of a complete lighting retrofit of all 59 exterior HPS fixtures installed on the exterior of City Hall and the Police Department. A building-by-building lighting survey was not completed for this project. Site contacts provided the evaluation team with a full project invoice that detailed the total number of LED fixtures installed as part of this retrofit. Site contacts confirmed that baseline technology for this measure was HPS fixtures.

Savings for the two lighting measures, EEM1 & EEM2, were calculated line-by-line using the following algorithm:

$$\textit{Annual savings (kWh)} = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Pre-retrofit annual hours of operation for usage group
PostRunHrs	= Postretrofit annual hours of operation for usage group (assumed to be the same as no measures involved the installation of occupancy sensors)

HVAC interactive effects were not accounted for in the ex ante savings estimates and therefore they are not included in the ex post analysis.

Measure 3 – Install UV Emitter in Rooftop HVAC

EEM3 consisted of the installation of 24 Steril-aire SE 1 VO ballasts and light bulbs in 24 packaged rooftop HVAC units that serve City Hall and the Police Department. These bulbs reportedly kill viruses and bacteria on the evaporator coil, reducing fan energy as well as increasing system efficiency through increased heat transfer from the coil to the supply air stream. Site contacts provided invoices detailing the total number of units installed as part of this measure. Savings calculations for this measure were not included in the program documentation.

Project Evaluation

An ERS engineer visited the facility on May 26, 2012, to verify the installation of each measure and the hours of operation with site staff and ensure that the equipment specifications met those listed in the program documentation. Due to the large number of fixtures, space types,

and the lack of a complete lighting survey, the evaluation team could not gather statistically significant metered lighting data and stay within the project budget and timeline. Consequently, the evaluation team inspected a large portion of the light fixtures installed as part of this project and verified the hours of operation with site personnel.

Measure 1 – Retrofit Indoor Light Fixtures

On-site verification activities confirmed that the lighting measure was installed as detailed in the invoices provided by the site contact. ERS verified the installation of 154 fixtures in twenty rooms. These rooms represented 26 percent of the total number of fixtures and 22 percent of the total measure savings.

Interviews with site contacts revealed that the annual hours of operation for City Hall are 2800 hours per year, Council Chambers are 192 hours per year, and the Police Department is 8000 hours per year.

For each fixture type the evaluation team verified that the lamps and ballasts installed matched those listed in the project invoice. The evaluation team found no major discrepancies affecting the total project savings.

Figure 71, Figure 72, and Figure 73 show sample light fixtures and ballasts surveyed as part of the inspection process.

Figure 71: City Hall – City Council Chambers, CFL Fixtures

Photo Credits: DNV KEMA

Figure 72: City Hall – Standard Ballast Factor Fixture, Lamps

Photo Credit: DNV KEMA

Figure 73: City Hall – Standard Ballast Factor Fixture, Ballast

Photo Credit: DNV KEMA

Measure 2 – Retrofit Outdoor Light Fixtures

On-site verification activities confirmed that the installed fixtures were LED units, as detailed in the invoices provided by the site contact. ERS verified the installation of twenty fixtures. These fixtures represented 33 percent of the total number of fixtures and 33 percent of the total measure savings.

For both fixture types, the evaluation team verified that the units matched those listed in the project invoices. The evaluation team recalculated savings line-by-line.

Figure 74 shows a sample light fixture surveyed as part of the inspection process.

Figure 74: Police Department – Exterior LED Fixture

Photo Credit: DNV KEMA

Measure 3 – Install UV Emitter in Rooftop HVAC

On-site verification activities confirmed that rooftop HVAC units were equipped with UV sterilization bulbs on the evaporator coils as listed in the project invoices. The equipment was installed on Carrier RTUs ranging in size from 3 to 5 tons.

For EEM3, the site inspection revealed that UV light emitters were installed as described in the limited program documentation. As stated in the M&V plan, because there were no savings calculations included in the program documentation, the site contacts could not provide savings calculations, and the evaluation timeline did not allow for pre and postinstallation measurement, the evaluation team was not able to verify the calculation methodology for this measure.

Figure 75 shows a sample HVAC unit surveyed as part of the inspection process.

Figure 75: Police Department – UV Light Emitter Inside Packaged HVAC Unit

Photo Credit: DNV KEMA

Savings Results

Taking into account both lighting measures for this site (EEM1 and EEM2), the Seal Beach project resulted in 99,526 kWh in annual gross energy savings. Peak demand savings of 2.58 kW

were estimated using coincident demand factors from DEER 2011. A breakdown of savings by individual measure is presented in Table 189 at the beginning of this report. The ex ante savings estimates, which were acquired from the program's monthly status reports, are also provided as a point of reference.

Savings for EEM3 were excluded from this evaluation due to a lack of savings calculations in the program documentation, and evaluation calculations indicating savings are likely to be negative.

Discussion

Measure 1 - Retrofit Indoor Light Fixtures

On-site verification activities confirmed that the lighting measure was installed as detailed in the invoices provided to the evaluation team by the site contact. The evaluation team verified the installation of 154 fixtures. These fixtures represented 22 percent of the total ex post measure savings. The annual hours of operation for both the administration building and the public health building were determined through discussion with site staff and personnel.

Measure 2 – Retrofit Outdoor Light Fixtures

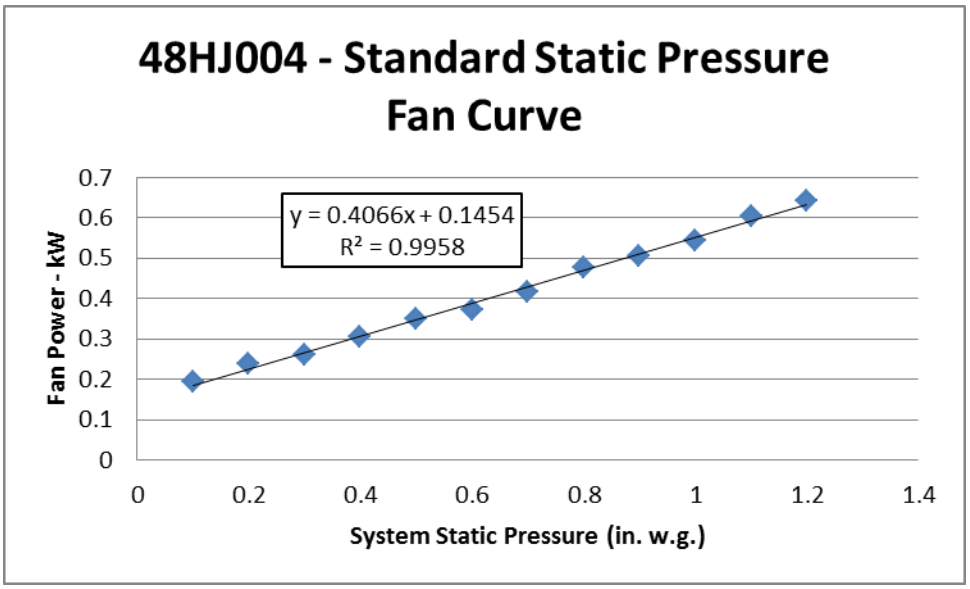
On-site verification activities confirmed that the lighting measure was installed as detailed in the invoices provided to the evaluation team by the site contact. The evaluation team verified the installation of 154 fixtures. These fixtures represented 33 percent of the total ex post measure savings.

Measure 3 – Install UV Emitter in Rooftop HVAC

On-site verification activities confirmed that the lighting measure was installed as detailed in the invoices provided to the evaluation team by the site contact. The evaluation timeline did not allow for pre and post monitoring of this measure. Included below are the fan curves for the rooftop HVAC units affected by this measure. These curves were developed from the manufacture's performance tables for each of the units installed at the site. A potential methodology for estimating the impact of these UV bulbs on the system performance is also included below. The measure proposes to reduce HVAC energy by two means: reducing supply fan energy by reducing the pressure drop across the evaporator coil and increasing compressor efficiency through increased heat transfer across the evaporator coil.

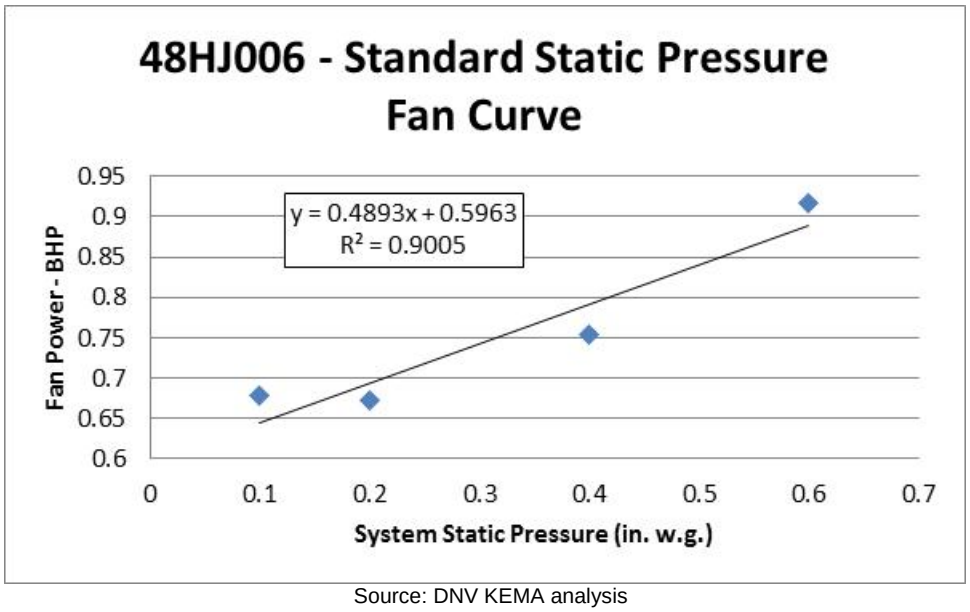
The calculations below assume an optimistic scenario where the UV light is able to reduce the total pressure drop across the evaporator coil by 20 percent. The savings associated with improved heat transfer is assumed to be of the same order of magnitude as the fan savings as the building load is not affected by the measure. In addition, the calculations include the electrical penalty associated with operating the 40W UV bulb 8760 hours per year. The analysis results indicate that continuous UV emitter operation uses much more energy than is potentially saved by the HVAC system.

Figure 76: 3-ton Rooftop HVAC Unit Supply Fan Curve at 1200 CFM



Source: DNV KEMA analysis

Figure 77: 5-ton Rooftop HVAC Unit Supply Fan Curve at 2000 CFM



Source: DNV KEMA analysis

Figure 78: EEM3 - Simple Energy Balance Estimation

Site Constants			
Units	24		
Ave Fan Power	0.74	kW	
Annual Heating & Cooling Hours of Operation	3,000	Hrs	
Electric Penalty			
UV Lamp Power	40	Watts	
UV Lamps Annual Hrs	8,760	Hrs	
Total Lamp Energy Usage	-14,717	kWh	
Supply Fan Impact			
Coil Pressure Drop	0.10	(in. w.g.)	*Specific to these Carrier Units
Est Pressure Drop Improvement	20%		
Pressure Drop Reduction	0.02	(in. w.g.)	
Average Supply Fan Power	0.73	kW	
Fan Curve Savings Constant	0.46	(in w.g.)/kW	* Weighted Average - Specific to these Carrier Units
Total Unit & Site Savings			
Fan kW Savings per unit	0.0092	kW	
Post Installation Fan power per unit	0.721	kW	
Annual Fan Savings	662	kWh	
Est Cooling Capacity Savings	700	kWh	* Est as same order of magnitude
Total Savings	1,362	kWh	
Total Impact	**-13,354**	**kWh**	

Source: DNV KEMA analysis

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1). The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the EEM implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 191 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 191: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	99,526	2.58	0.0
2	2012	99,526	2.58	0.0
3	2013	99,526	2.58	0.0
4	2014	99,526	2.58	0.0
5	2015	99,526	2.58	0.0
6	2016	99,526	2.58	0.0
7	2017	99,526	2.58	0.0
8	2018	99,526	2.58	0.0
9	2019	99,526	2.58	0.0
10	2020	99,526	2.58	0.0
11	2021	99,526	2.58	0.0
12	2022	99,526	2.58	0.0
13	2023	99,526	2.58	0.0
14	2024	99,526	2.58	0.0
15	2025	99,526	2.58	0.0
Total		1,492,890 kWh		0.0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Amador, County of (CBG-09-158)

Site Summary

This project consisted of two measures. The EEM1 involved replacing six HVAC units with new, energy efficient units at the county jail and at the Sherriff's office. The EEM2 consisted of retrofitting the interior lighting at the county jail, Sherriff's office, District Attorney's office, General Services Administration office, as well as the library's main branch and the Probation office. The retrofit included replacing T12 and T8 linear fluorescent equipment with reduced wattage T8 equipment. Table 192 below summarizes the energy savings of each measure.

Table 192: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 - HVAC replacement	33,692	19.5	318	33,743	23.7	327	100%	103%
EEM2 - T12/T8 to reduced wattage T8	76,312	24.1	N/A	76,408	27.8	N/A	100%	N/A
Total	110,004	43.6	318	110,151	51.6	327	100%	103%

Source: DNV KEMA analysis

There is little difference in the HVAC and lighting measure ex ante and ex post savings. The HVAC units were found to be as reported in the project documentation. A sample of lighting fixtures was inspected and no discrepancies were found compared to the list of lighting retrofits provided by the site contact.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For the lighting measures, Baseline 1 and 2 are identical. For the HVAC units, Baseline 1 is based on the replaced unit's efficiency and Baseline 2 is based on minimum equipment

efficiency requirements (Title 24- 2008 BEES). DEER provides an EUL of 15 years for lighting and 15 years for HVAC.

Table 193: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline 1	1,652,265	51.6	4,905
Baseline 2	1,261,035	47.5	4,905

Source: DNV KEMA analysis

Project Description

This project consisted of two measures. The EEM1 involved replacing six HVAC units with new, energy efficient units at the county jail and at the Sherriff's office. The EEM2 consisted of retrofitting the interior lighting at the county jail, Sherriff's office, District Attorney's office, General Services Administration office, as well as the library's main branch and the Probation office. The retrofit included replacing T12 and T8 linear fluorescent equipment with reduced wattage T8 equipment.

EEM1 – HVAC Replacement

This measure consisted of replacing six HVAC units ranging in size from 2-Tons to 7.5-Tons. A 7.5-Ton unit and a 5-Ton unit were installed at the county jail and the remaining 4 units, a 7.5-Ton unit, two 5-Ton units and a 2-Ton unit were installed at the Sherriff's office.

EEM2 – T12/T8 to Reduced Wattage T8

In this measure existing linear fluorescent fixtures containing T12 equipment as well as fixtures containing F32T8 equipment were retrofitted with reduced wattage (28 W) T8 equipment. In addition, incandescent lamps were retrofitted with compact fluorescent lamps (CFL).

Project Evaluation

The evaluation team visited the city on May, 15, 2012 to verify the installation of the HVAC units as well as inspect a sample of the retrofitted linear fluorescent fixtures at each location.

Figure 79 shows a sample HVAC nameplate surveyed as part of the inspection process. Figure 80 shows a reduced wattage T8 lamp surveyed during the site visit.

Figure 79: Nameplate for 5-ton HVAC Unit

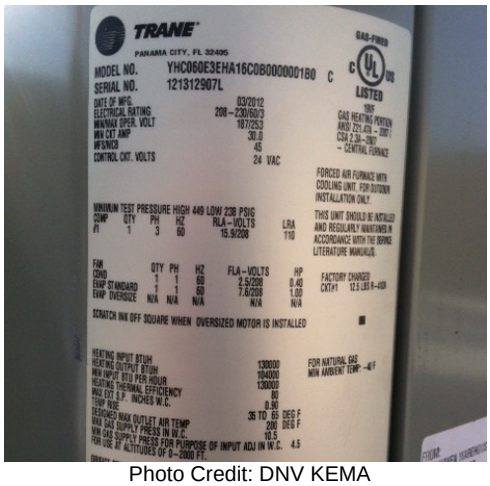


Photo Credit: DNV KEMA

Figure 80: Sample 28 W T8 Lamp

Photo Credit: DNV KEMA

Savings Results

The ex post savings calculation resulted in 114,244 kWh in annual energy savings. Demand savings of 54.5 kW were also realized.

Discussion

An analysis of the measures was conducted using the provided documentation and information gathered during the site visit.

EEM1 – HVAC Replacement

All of the HVAC units were inspected and verified to be the same type and size as specified in the project documentation. The replaced HVAC equipment was estimated by site staff to be approximately 30 years old. No performance discrepancies were reported. A weather bin analysis was used to estimate both electric and natural gas energy savings. Model inputs included HVAC size, efficiency, and occupancy schedule data collected while on-site, as well as local climate zone weather data (CZ11). A 10 percent degradation factor was included to account for the age of the equipment.

EEM2 – T12/T8 to Reduced Wattage T8

The evaluation inspected a sample of fixtures at each location. One of each type of fixture was opened to verify the lamp wattage and ballast factor. The site contact verified the operating hours of each building. Most of the buildings operate from 8 a.m. to 5 p.m., Monday through Friday. The jail and sheriff's office operate 24 hours per day, 7days per week, and the General Services Administration office operates from 6 a.m. to 5 p.m., Monday through Friday.

Ex Post Life-cycle Savings

Energy savings were calculated relative to both Baseline 1 and Baseline 2. It takes into account the equipment's operating efficiency along with the control strategies found at that time. For HVAC, Baseline 1 is based on the replaced equipment's estimated efficiency and Baseline 2 is based on minimum code requirements.

Table 194 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 194: Life-cycle Savings

		Baseline 1			Baseline 2		
Life-cycle	Year	Electric Energy Savings (kWh/yr)	Demand Reduction (kW)	Therms Savings	Electric Energy Savings (kWh/yr)	Demand Reduction (kW)	Therms Savings
1	2012	110,151	51.6	327	110,151	51.6	327
2	2013	110,151	51.6	327	82,206	47.5	327
3	2014	110,151	51.6	327	82,206	47.5	327
4	2015	110,151	51.6	327	82,206	47.5	327
5	2016	110,151	51.6	327	82,206	47.5	327
6	2017	110,151	51.6	327	82,206	47.5	327
7	2018	110,151	51.6	327	82,206	47.5	327
8	2019	110,151	51.6	327	82,206	47.5	327
9	2020	110,151	51.6	327	82,206	47.5	327
10	2021	110,151	51.6	327	82,206	47.5	327
11	2022	110,151	51.6	327	82,206	47.5	327
12	2023	110,151	51.6	327	82,206	47.5	327
13	2024	110,151	51.6	327	82,206	47.5	327
14	2025	110,151	51.6	327	82,206	47.5	327
15	2026	110,151	51.6	327	82,206	47.5	327
Total		1,652,265		4,905	1,261,035		4,905

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Mendocino, County of (CBG-09-164)

Site Summary

The County of Mendocino was awarded funds to retrofit aging HVAC and lighting equipment in Ukiah. There were three main EEMs for this project which affected various buildings throughout the city. The EEMs included a lighting upgrade, replacements of worn out packaged HVAC units, and the implementation of DDC controls which allowed for tighter scheduling of the HVAC units.

Ex post electric and gas energy savings were estimated at 335,322 kWh and 3,996 therms for this project and represents 77 percent and 126 percent of the ex ante estimates for electric and gas energy savings, respectively (Table 195). The differences in energy savings can be attributed to methodologies used in calculating energy consumption. The ex post methodology used a more rigorous methodology based on monitored data whereas the ex ante methodology relied largely on simplified equations and assumptions. Details can be found in the discussion section of this report.

Table 195: Energy Savings Summary

Measure	Ex Ante[37]			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 - Lighting Retrofit	389,451	Not reported	0	305,993	95.9	0	79%	N/A
EEM2 - HVAC replacement	7,719	Not reported	161	14,955	10.8	390	194%	242%
EEM3 - DDC Controls	41,061	Not reported	2,934	14,374	0.0	3,606	35%	123%
Total	438,231	0.00	3,095	335,322	106.7	3,996	77%	129%

Source: DNV KEMA analysis

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures

37 Ex ante values for EEM-2 reflect the scope of 3 HVAC units replaced.

- Baseline 2, the dual baseline, uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment is exceeded

The overall results from Table 195 yield a life-cycle energy savings of 5,029,833 kWh and 59,939 therms (Table 196) for Baseline 1 and 4,822,010 kWh and 54,486 therms for Baseline 2.

Table 196: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1	5,029,830	1,600	59,940
Baseline 2	4,822,014	1,451	54,480

Source: DNV KEMA analysis

Project Description

The projects implemented at Ukiah included a comprehensive interior lighting upgrade, HVAC replacements for three of the oldest units, and a DDC upgrade to control the starting and stopping times of eight HVAC units. The project focused largely on the main jail facility and adjoining support buildings, but some of the lighting work also included other city buildings. Specifically, the following measures were implemented throughout the city of Ukiah.

- EEM1: *Lighting retrofit* – The lighting system at the main jail and other city buildings primarily used T-12 based fluorescent lighting. This measure replaced this lighting system with next generation T-8 lamps and fixtures.
- EEM2: *HVAC replacement* – A number of the packaged air-conditioning units were past their useful life and ran inefficiently. This measure replaced three units with high efficiency models to save gas and electric energy.
- EEM3: *DDC control* – The existing system used to control the start and stop times for the HVAC units did not allow for individual control of the units. The new DDC controls would ideally allow for tighter regulation of the start and stop times based on need.

Ex Ante Savings

According to documents provided to DNV KEMA, the following was used to determine energy savings for each of the measures implemented at this site.

EEM1: Lighting retrofit – A spreadsheet provided to DNV KEMA by the site contact showed pre and postretrofit wattages and quantities of the lighting system for each building. Energy savings were calculated using the standard equation shown below.

$$Savings = \left(kW_{pre} - kW_{post}\right) \times hours$$

Where *Savings* is the electric energy savings of each fixture, *kW* is the fixture's pre and post power draw, and *hours* is an estimate of each fixture's annual hours of operation.

EEM2 & 3: HVAC replacement – A spreadsheet provided to DNV KEMA by the Energy Commission showed that the energy savings estimated used the following formula to calculate energy consumption for each unit before and after project implementation.

$$Energy = \frac{12}{SEER} \times Tons \times Hours \times Loading$$

Where *Energy* is the energy consumption of the unit in kWh, *SEER* is the unit efficiency rating, *Tons* is the unit's rated cooling capacity, *Hours* is an estimate on how often the unit is on a year, and *Loading* is an adjustment factor estimated at 25 percent.

To estimate energy savings for the HVAC replacement, the existing SEER value of the unit was estimated to be 8 to 9 SEER and de-rated by 10 percent to account for degradation. In the efficient case, a new SEER value was inputted to the equation to calculate the postretrofit energy consumption. This value was reduced by another 10 percent presumably to account for duct sealing effects. The energy savings is simply the difference of the baseline and postretrofit energy consumption values.

Similarly, for gas energy savings, the following was used to determine baseline and postretrofit consumptions.

$$Gas\ energy = \frac{Input \times Hours \times Loading}{100{,}000}$$

Where *Gas energy* is the gas energy consumption in therms, *Input* is the furnace gas input rating in Btu/h, *Hours* is an estimate on how often the unit is on a year, and *Loading* is an adjustment factor estimated at 20 percent.

To estimate energy savings for the furnace replacement, the existing unit efficiency rating was estimated at 78 percent AFUE while the new unit's efficiency was estimated at 80 percent AFUE. The calculations also assume that 10 percent of the existing gas energy is saved due to duct sealing, similar to the cooling calculations. The difference in consumption for the baseline and postretrofit cases is the gas energy savings.

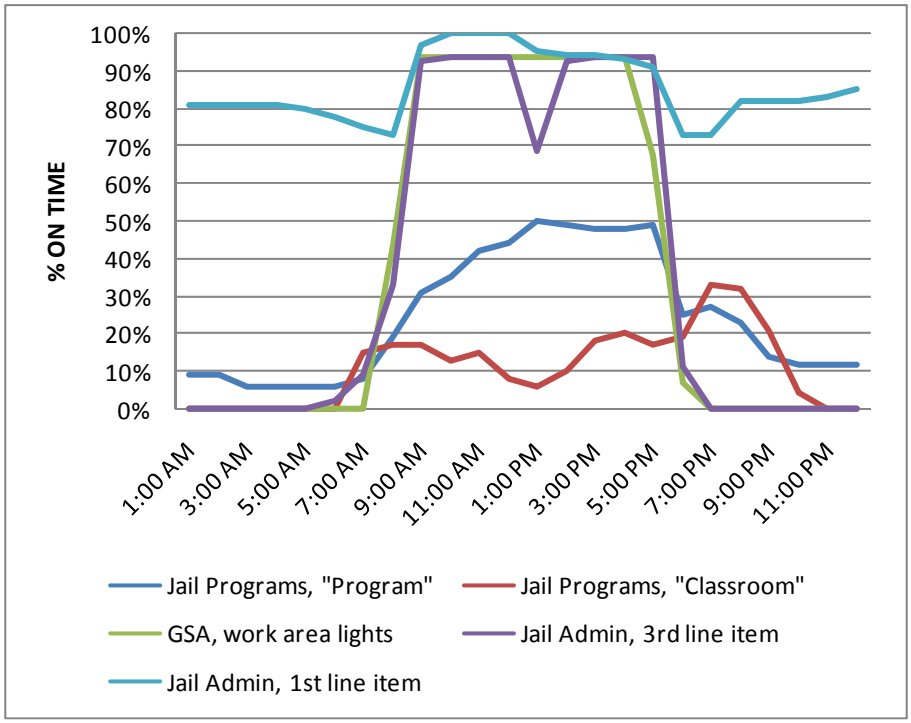
EEM3: DDC control – The energy savings from the DDC controls were calculated by assuming the 8 units ran 10 hours a day instead of 12 using the same equation as in EEM2. In addition, 39 equivalent operating hours a year was removed in the efficient case to account for the units turning off during holidays. The average efficiency rating of the unit was assumed at SEER 8 and 70 percent AFUE.

Project Evaluation

A DNV KEMA field engineer visited the project's sites on May 24th, 2012 to verify and monitor the new lighting system, the new HVAC units, and the HVAC units affected by the DDC controls.

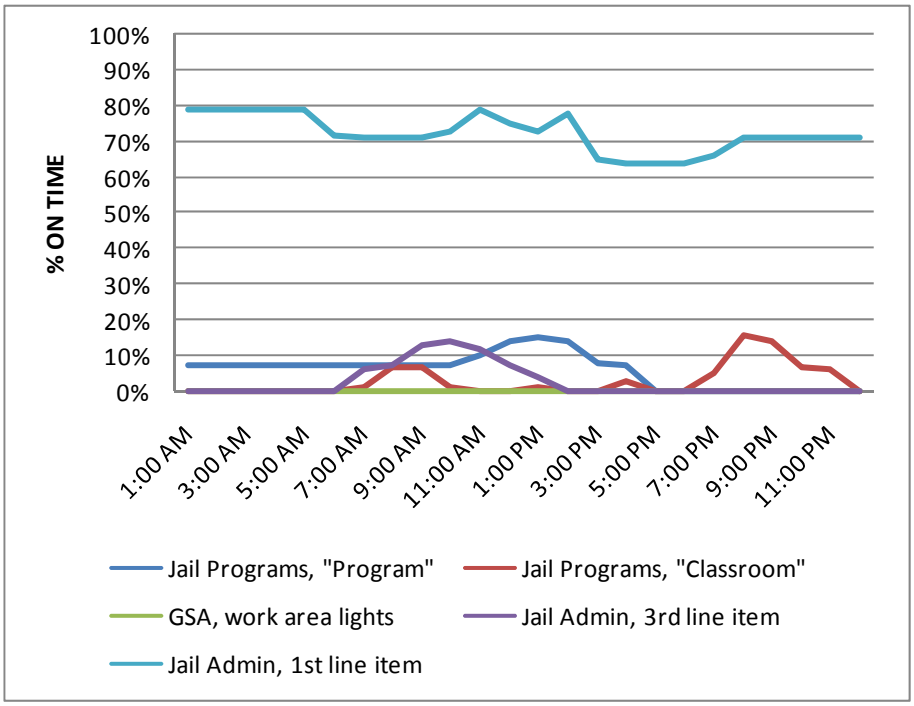
EEM1: Lighting retrofit – The spreadsheet provided to DNV KEMA was used to verify the new fixtures that were installed. In addition, five time-of-use (TOU) loggers were placed throughout some of the buildings to monitor time-of-use and to verify the assumptions used in the analysis. The fixtures to be monitored were chosen based on the magnitude of energy savings claimed and accessibility, but were also limited due to placement restrictions (most of the fixtures replaced were at the Main Jail and no equipment was allowed to be installed at those locations). DNV KEMA also verified the general hours of operation for some of the buildings as a quality check on the fixture's total annual hours of use. The data collected on these fixtures can be summed up using Figure 81 and Figure 82 below.

Figure 81: Fixture "ON" Time Percentages During a Typical Weekday



Source: DNV KEMA analysis

Figure 82: Fixture "ON" Time Percentages During a Typical Weekend Day



Source: DNV KEMA analysis

Data from the TOU loggers were extrapolated to the entire year and yielded estimates on time-of-use for these specific fixtures in the range of 762 hours to 7,166 hours depending on fixture. These values are more accurate and fixture specific and therefore were used in the ex post analysis spreadsheet. In addition, the hours of use were changed for a number of fixture locations to reflect the building's hours of operation as stated by the occupants and site contact. Overall, these changes had a negative impact on the energy savings for this measure.

Energy savings were calculated using the following equation and was similar to the one used in the ex ante analysis:

$$Savings = \left(kW_{pre} - kW_{post}\right) \times hours$$

Where *Savings* is the electric energy savings of each fixture, *kW* is the fixture's pre and post power draw, and *hours* is an estimate of each fixture's annual hours of operation using either logger data, the building's stated hours of operation, or the original estimates (as available in that order).

The analysis for this measure yielded an energy savings of 305,993 kWh.

EEM2: HVAC replacement – The initial project files claimed that there were 8 units replaced with high efficiency units. However, the scope was reduced to three units, which is consistent with what DNV KEMA found on-site. The tonnage and SEER values for these units also did not match what was claimed. Table 197 summarizes the discrepancies found during the verification for this measure.

Table 197: HVAC Replacement Discrepancies Found During Measure Verification

Location	Ex Ante Claimed Unit Tonnage(s)	Ex Ante Claimed Efficiency (SEER)	Result of Site Inspection
Main Jail	Two 5 ton units	SEER 15	Found, but SEER 13, tonnage correct
Jail Kitchen	One 5 ton unit	SEER 15	Found, but EER 11.3 and unit is 10 tons

Source: DNV KEMA analysis

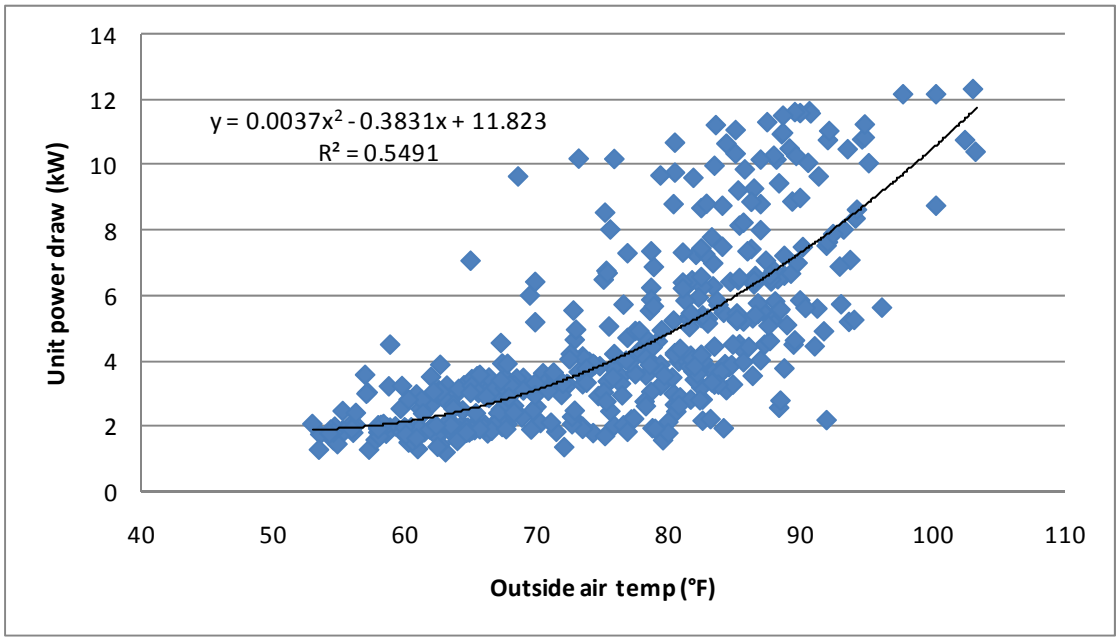
At the Main Jail and Jail Kitchen where the new units were found, DNV KEMA attached power meters to the incoming power lines to measure energy use over a 6 week period during cooling season. The data was analyzed using a regression analysis to approximate each unit's loading profile. Next, energy savings were estimated using a bin analysis using outside air temperature. The algorithm can be approximated using the following formula for each outside air temperature bin:

$$Energy = \eta \times tons \times loading \times hours$$

Where *Energy* is the energy consumption of the unit in kWh, η is the unit efficiency rating in kW/ton using calculated from the SEER or EER rating, *Tons* is the unit's rated cooling capacity, *Hours* is the number of hours present in each temperature bin, and *Loading* is a cooling load function based on the data collected during the evaluation site visit.

For the 10 ton unit at the Jail Kitchen, the data collected yielded the following regression curve for loading which was used in the algorithm stated above.

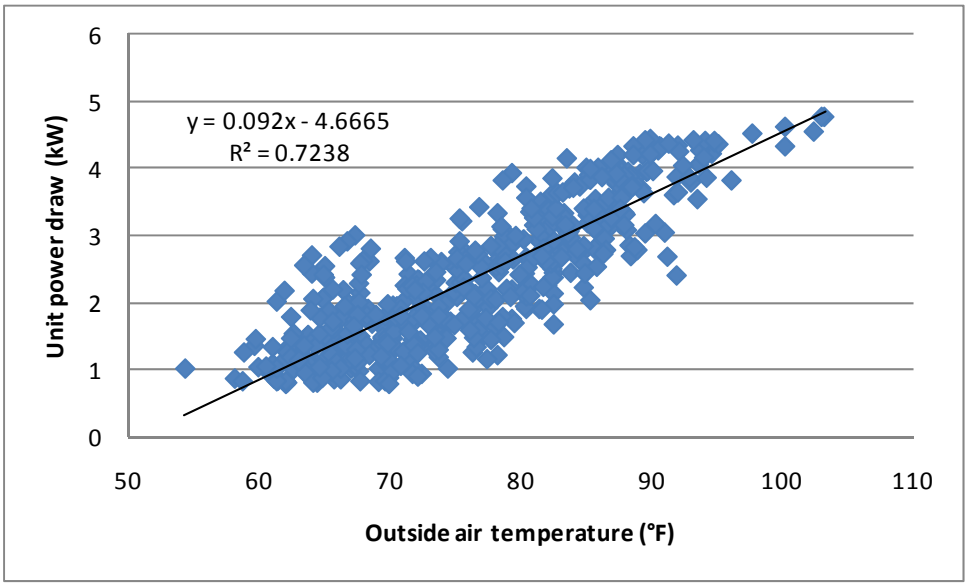
Figure 83: Regression Curve for 10-ton Rooftop Unit at Jail Kitchen



Source: DNV KEMA analysis

Similarly, the five ton unit at the Main yielded the following regression curve:

Figure 84: Regression Curve for 5-ton Rooftop Unit at the Main Jail



Source: DNV KEMA analysis

To calculate the baseline energy consumption, DNV KEMA assumed that the old, pre-existing units had a SEER value of 7.38 (1998 minimum Title 24 standards de-rated by 10 percent) and

the energy consumption was calculated with the same algorithm and loading patterns. Energy savings for each unit is simply the difference between the baseline and postretrofit energy consumption.

In this way, the energy savings for this measure was calculated at 14,955 kWh and includes energy savings for all three units replaced.

Gas savings were estimated in a similar fashion using the bin analysis above but modified for gas energy consumption. The heating load is assumed as linear with outside air temperature and increases as outside air temperature drops.

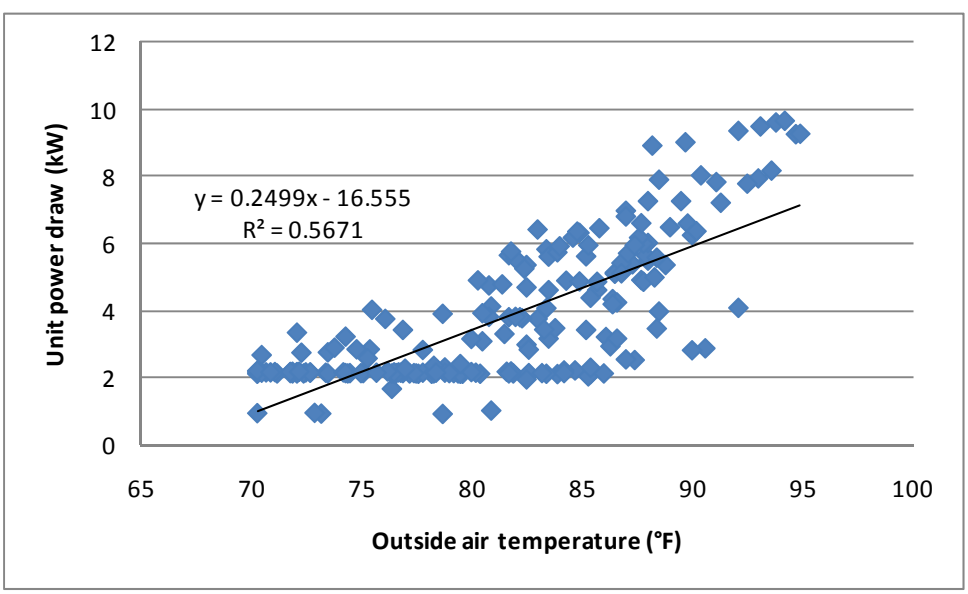
$$Gas\ energy = \frac{Output}{\eta \times 100{,}000} \times loading \times hours$$

Where Gas energy is the gas energy consumption in therms, Output is the unit's rated heating output, η is the furnace's efficiency, loading is the heating load function assumed linear with outside air, and hours is the number of heating hours for that temperature bin.

Using this equation, the total energy saved from the furnace portion of the HVAC replacement was calculated at 390 therms. This assumes a baseline efficiency of 78 percent AFUE and a furnace replacement efficiency of 80 percent AFUE.

EEM3: DDC control – The electric and gas energy savings analysis for the DDC controls uses essentially the same algorithms as in EEM2. The "loading" profile was created from data collected from one of the older five ton unit that was on DDC controls. Below is regression curve that was generated from data collected at this unit (Figure 85).

Figure 85: Regression Curve for 5-ton Rooftop Unit at Administration Building



Source: DNV KEMA analysis

Data from the six weeks of monitoring suggested that the efficiency of these units were near 6.2 SEER. This value was used in the algorithms. To determine energy savings from the DDC controls, the schedule in the postretrofit case were modeled as identical to the data (from 5 a.m. to 6 p.m.). The site contact indicated he was not certain of the how the units operated but suspected the new controls allowed the units to turn off one hour earlier. Due to the lack of preretrofit data and the high level of uncertainty of how the units operated in the baseline case, DNV KEMA opted to make conservative assumptions for the baseline operating schedule. Therefore, in the baseline case, the units were assumed to run one hour longer (5 a.m. to 7 p.m.) during the evening time. This is in contrast to the ex ante assumptions of two hours, presumably for an optimized start/stop for the morning and evening periods. The data shows the DDC did indeed optimize the stop time and turned off the unit at 6 p.m., but the start time remained relatively early (the data shows the fan turns on at 5 a.m.).

The analysis yielded 14,374 kWh and 3,606 therms of energy savings.

Savings Results

Considering the implementation of all three EEMs, this site saved 335,322 kWh of electric energy and 3,996 therms of gas energy. Table 195 breaks down the ex post energy savings by measure (first page). The ex ante energy savings are also provided for comparison. Below is a discussion on the differences between ex post and ex ante energy savings.

Discussion

EEM1: Lighting retrofit – Ex post energy savings for this measure was calculated at 305,993 kWh or 79 percent of the ex ante claims. This value is different because the annual hours of operation for a number of fixtures differed between ex ante and ex post calculations. DNV KEMA started with the original spreadsheet provided by the site contact as the basis for the energy savings calculation and changed a number of key fixtures' hours of operation based on monitored time-of-use data collected during the evaluation or stated hours. While some fixtures' annual hours of operation were revised downwards, others were revised upwards. In addition, lights at the Juvenile Probation location were given zero savings because the retrofit did not involve EECBG funds. The combination of these adjustments resulted in the 79 percent realization rate.

EEM2: HVAC replacement – Ex post energy savings for this measure was calculated at 14,955 kWh and 390 therms. Compared to the ex ante numbers, this resulted in a realization rate of 194 percent and 161 percent for electric and gas energy savings, respectively. Energy savings for this measure were different because the calculation methodologies were not the same and therefore, a divergence in the energy savings claim is expected. The ex post analysis used a more rigorous analysis approach. These ex post energy savings reflect the revised scope of only 3 units replaced in comparison to the 8 units that were planned.

EEM3: DDC control – Similar to EEM2, energy savings for this measure were different because the calculation methodologies were not the same. DNV KEMA employed a more robust methodology which capitalized on energy monitoring and power measurements (high rigor) whereas the ex ante methodology relied on estimated values (low rigor). In addition, the ex ante

algorithm is too simple to accurately gauge energy consumption of the units due to the DDC controls. The algorithm does not account for HVAC loading during hours when outside air is low which occurs often for this location and is significantly impacted towards the evenings when the impact of the DDC controls are felt. That is, when the DDC controls turn off the HVAC unit in the late afternoon, the building's zones have already begun to cool down and will not need as much cooling (also partly due to a more moderate climate zone). However, the equation is setup in such a way that it assumes the HVAC unit operates at full load at all those hours, regardless of cooling need, which is rarely the case.

The improved rigor level applies only to the electric energy savings.

The methodology used to evaluate therms energy savings, however, have similar rigor levels although the ex post also incorporates heating need based on outside air temperatures. Actual in situ energy savings may differ. Typically, however, higher rigor level assessments are difficult to implement for gas end uses due to time and cost investments necessary to estimate energy consumption. For purposes of this evaluation, the rigor level is adequate and the energy savings claims are within reasonable range.

Ex Post Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

For the lighting and DDC measures, baselines 1 and 2 are identical since the original scenarios were already code compliant. For the HVAC replacement measure, both Baseline 1 and Baseline 2 are considered. Baseline 1 is simply what the efficiency of the existing packaged air conditioners would be operating at if no replacement was implemented. Because the existing units had already been removed, it is not possible to determine the existing efficiency rating at the time of the evaluation. DNV KEMA estimated this efficiency using an older version of Title 24 code assumed to be in place when the original unit was installed and then de-rating the equipment by 10 percent to account for degradation. A second baseline (Baseline 2) was also considered which took into account what current energy codes would require as the minimum efficiency standards (2008 Title 24 code). While the HVAC units were past their EUL, DNV KEMA assumed a RUL of 1 since the units were still in operation.

Details of this calculation are shown in Table 128.

Table 198: Values Used in Life-cycle Savings Calculations by Measure

Measure	Baseline 1		Baseline 2		EUL (years)	RUL (years)
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)		
EEM1 - Lighting Retrofit	305,993	0	305,993	0	15	NA
EEM2 - HVAC replacement	14,955	390	111	0	15	1
EEM3 - DDC Controls	14,374	3,606	14,374	3,606	15	NA

Source: DNV KEMA analysis

When considering Baseline 1 over the entire life of the measure, this project yields an estimated energy savings of 5,029,830 kWh (Table 199). Under Baseline 2 (Table 200) the life-cycle savings is 4,822,014 kWh.

Table 199: Baseline 1 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	335,322	106.7	3,996
2	2012	335,322	106.7	3,996
3	2013	335,322	106.7	3,996
4	2014	335,322	106.7	3,996
5	2015	335,322	106.7	3,996
6	2016	335,322	106.7	3,996
7	2017	335,322	106.7	3,996
8	2018	335,322	106.7	3,996
9	2019	335,322	106.7	3,996
10	2020	335,322	106.7	3,996
11	2021	335,322	106.7	3,996
12	2022	335,322	106.7	3,996
13	2023	335,322	106.7	3,996
14	2024	335,322	106.7	3,996
15	2025	335,322	106.7	3,996
Life-cycle	Total	5,029,830	1,600.5	59,940

Source: DNV KEMA analysis

Table 200: Baseline 2 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	335,322	107	3,996
2	2012	320,478	96	3,606
3	2013	320,478	96	3,606
4	2014	320,478	96	3,606
5	2015	320,478	96	3,606
6	2016	320,478	96	3,606
7	2017	320,478	96	3,606
8	2018	320,478	96	3,606
9	2019	320,478	96	3,606
10	2020	320,478	96	3,606
11	2021	320,478	96	3,606
12	2022	320,478	96	3,606
13	2023	320,478	96	3,606
14	2024	320,478	96	3,606
15	2025	320,478	96	3,606
Life-cycle	Total	4,822,014	1,451	54,480

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT EECBG

South El Monte, City of (CBG-09-167)

Site Summary

The City of South El Monte applied for EECBG funds for three EEMs: replacement of five aging rooftop packaged HVAC systems serving the Senior Center; retrofits of interior and exterior lighting fixtures and lighting controls at the South El Monte City Hall, City Yard, Community Center, Mini Center, New Temple park, Old Yard, California State Route 60 Overpass, Senior Center, and Shively Park facilities; and installation of occupancy controls on two vending machine located within the Community Center facility.

DNV KEMA performed site visits at six of the nine city facilities that received EECBG funded energy efficiency retrofits: the South El Monte City Hall, Community Center, Senior Center, California State Route 60 Overpass, New Temple Park, and Shively Park facilities. During the site visits, DNV KEMA verified the quantity, manufacturers, and model numbers of the all the installed HVAC equipment and a sample of the lighting equipment. DNV KEMA also gathered HVAC operational schedules and set point temperatures for all the replaced systems.

Spreadsheet analysis was used to estimate energy savings for all measures using a combination of site findings and literature reviews. The analysis yielded an overall annual electric energy savings of 93.3 percent and natural gas savings of 17.9 percent when compared to ex ante estimates. The energy and power savings by measure are provided in Table 201.

Table 201: Energy Savings Summary by Measure Category

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand Reductio n (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand Reduction (kW)	Gas Energy (Therms)	Electric	Gas
Rooftop HVAC Units	7,462	12.13	257	8,343	12.70	46	111.8%	17.9%
Lighting Fixtures and Controls	119,672	32.63	-	111,836	30.66	-	93.5%	N/A
Vending Machine Controls	1,612	Not Reported	-	0.0	0.00	-	0.0%	N/A
Total	128,746	44.76	257	120,179	43.36	46	93.3%	17.9%

Source: DNV KEMA analysis

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment is exceeded.

The overall results from Table 202 yields a life-cycle energy savings of 1,802,685 kWh, life-cycle demand savings of 650 kW-years, and life-cycle natural gas energy savings of 690 therms when considering the buildings' existing conditions. Using a dual baseline defined as Baseline 2, the life-cycle savings total 1,710,495 kWh, 510 kW-years, and 550 therms as shown in Table 202.

Table 202: Ex Post Life-cycle Savings Totals

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1	1,802,685	650	690
Baseline 2	1,710,495	510	550

Source: DNV KEMA analysis

Project Description

Measure 1: RTU HVAC Systems

This measure involved the replacement of five RTUs at the city's Senior Center facility. These existing and replacement equipment is listed below:

- Two 10-ton packaged RTUs
  - Existing units
    - Model Number: 48TMD012
    - 10-ton cooling capacity, 10.1 SEER
      - 103 kBTU/hr heating capacity, 75 percent AFUE (Annual Fuel Utilization Efficiency)
  - Replacement units
    - Model Number: 48HCDD12
    - 10-ton cooling capacity, 11.5 EER
    - 148 kBTU/hr heating capacity, 82.2 percent AFUE
- One 7.5-ton packaged RTU
  - Existing units
    - Model Number: 48TMD008
    - 7.5-ton cooling capacity, 10.1 SEER
    - 100 kBTU/hr heating capacity, 80 percent AFUE
  - Replacement units
    - Model Number: 48HCDD08
    - 7.5-ton cooling capacity, 12 EER/15.2 SEER
    - 103 kBTU/hr heating capacity, 82.4 percent AFUE
- One 5-ton packaged RTU
  - Existing units
    - Model Number: 48TF4006
    - 5-ton cooling capacity, 8.5 EER/ 9.7 SEER
    - 50 kBTU/hr heating capacity, 80 percent AFUE
  - Replacement units
    - Model Number: 48HCLA06
    - 5-ton cooling capacity, 12.5 EER/15.2 SEER
    - 50 kBTU/hr heating capacity, 83.3 percent AFUE
- One 3-ton packaged RTU
  - Existing units
    - Model Number: 48TFN004
    - 3-ton cooling capacity, 8.7 EER/ 9.7 SEER
    - 72 kBTU/hr heating capacity, 80 percent AFUE
  - Replacement units
    - Model Number: 48HCLA04
    - 3-ton cooling capacity, 12.5 EER/15 SEER
    - 50 kBTU/hr heating capacity, 83.3 percent AFUE

Measure 2: Lighting Fixtures and Controls

This measure involved retrofits of existing interior and exterior lighting components to higher efficiency fixtures and bulbs as well as adding occupancy and daylight harvesting controls to existing interior fixtures. The planned lighting retrofits, organized by facility, are listed below:

- City Hall
  - 18 daylight harvesting lighting controls
  - Three occupancy sensor lighting controls
  - Two exit sign retrofit from incandescent to LED lighting
  - 26 interior lighting fixture retrofits from halogen to LED lighting
  - Nine parking lot light retrofits from HPS to induction lighting
  - One rooftop security light retrofit from mercury vapor to induction lighting
  - 14 parking lot light retrofits from mercury vapor to induction lighting
  - 3 parking lot light retrofits from MH to induction lighting
  - 1 4′ 1-lamp T12 to T8 (new gen) retrofits
  - 24 4′ 1-lamp T8 to T8 (new gen) retrofits
  - 200 4′ 2-lamp T8 to T8 (new gen) retrofits
  - 20 4′ 6-lamp T8 to T8 (new gen) retrofits
- City Yard
  - 34 4′ 2-lamp T8 to T8 (new gen) retrofits
- Community Center
  - 9 daylight harvesting lighting controls
  - 8 exterior fixture retrofits from HPS to induction lighting
  - 9 exterior fixture retrofits from incandescent to CFL lighting
  - 25 parking lot light retrofits from MH to induction lighting
  - 111 4′ 2-lamp T8 to T8 (new gen) retrofits
  - 6 4′ 4-lamp T8 to T8 (new gen) retrofits
  - 6 2′ 2 U-lamp to U-lamp (new gen) retrofits
- Mini Center
  - 25 4′ 2-lamp lamp T8 to T8 (new gen) retrofits
  - 99 4′ 4-lamp lamp T8 to T8 (new gen) retrofits
- New Temple park
  - 2 exterior fixture retrofits from HPS to induction lighting
  - 26 interior fixture retrofits from incandescent to CFL lighting
  - 4 exterior fixture retrofits from MH to induction lighting
- Old Yard
  - 6 fixture retrofits from MH to induction lighting
- California State Route 60 Overpass
  - 26 exterior 4′ 1-lamp retrofits from T12 to T8 lighting
- Senior Center
  - 14 daylight harvesting lighting controls
  - 6 exterior fixture retrofits from halogen to BR40 flood CFL lighting
  - 9 exterior fixture retrofits from HPS to induction lighting
  - 4 exterior fixture retrofits from incandescent to CFL lighting

    - 3 exterior fixture retrofits from MH to induction lighting
    - 2 4′ 2-lamp retrofits from T12 to T8 lighting
    - 106 4′ 2-lamp retrofits from T8 to T8 (new gen) lighting
    - 35 4′ 4-lamp T8 to T8 (new gen) retrofits
    - 1 2 U-lamp to U-lamp (new gen) retrofits
- Shively Park
    - 10 interior fixture retrofits from incandescent to CFL lighting
    - 3 parking lot fixtures retrofits from mercury vapor to induction lighting
    - 5 playground and parking lot fixture retrofits from MH to induction lighting

Measure 3: Vending Machine Controls

Vending machine occupancy sensor controls were to be installed on two vending machines located at the community center. These controls reduce the cooling and lighting load of the vending machines during periods of low occupancy.

Ex ante Savings

Measure 1: RTU HVAC Systems

The ex ante savings calculations for the package rooftop HVAC units were performed using spreadsheet based engineering calculations.

According to the calculation spreadsheet provided by the site contact, the ex ante kWh savings calculations were driven by the specific increase in EER/ SEER efficiency for each model replacement and an assumed 10 percent across the board efficiency increase due to duct sealing improvements. The calculations assumed annual hours of operation to be 1,507 hours and a cooling load factor of 25 percent for all models. The calculations also assumed the EER/SEER efficiency values for the existing equipment to be reduced by 10 percent due to age related performance degradation. This calculation method is represented by the equations below:

$$Annual\ kWh\ savings = \left[\#_{units} \times hours_{annual} \times 25\%_{load\ factor}\right] \times \left[\Delta kW + kW_{proposed} \times 10\%\ efficiency_{\ Duct\ Sealing}\right]$$

Where,

$$\Delta kW = kW_{existing} - kW_{proposed}$$
$$= \frac{Cooling\ Capacity\ (tons) \times 12\frac{kBTU/hr}{cooling\ ton}}{SEER\ or\ EER_{existing}} \times 1.1 - \frac{Cooling\ Capacity\ (tons) \times 12\frac{kBTU/hr}{cooling\ ton}}{SEER\ or\ EER_{existing}}$$

The ex ante kW electrical demand savings value is calculated as the sum of the ΔkW values for all replaced units.

The ex ante therms savings calculation relies on an across the board assumed heating efficiency gain of 2 percent more than existing equipment and the assumed 10 percent efficiency increase due to duct sealing improvements. Heating capacity is calculated by multiplying the total cooling capacity of all the replaced RTU, 35.5 tons, by 20,000 to produce the heating capacity for all units of 710,000 BTU/hr. The assumed 1,507 annual hours of operation is again used, but a heating load factor of 20 percent is employed for the therms savings calculation. This calculation method is represented by the equation below:

$$Annual\ therm\ savings = \left[\frac{Heating\ Capacity\ (\frac{BTU}{hr})}{100000\left(\frac{BTU}{therm}\right)} \times hours_{annual} \times 20\%_{load\ factor}\right] \times \left[2\%\ efficiency_{improvment} + 10\%\ efficiency_{\ Duct\ Sealing}\right]$$

Measure 2: Lighting Fixtures and Controls

The ex ante savings calculations for the lighting retrofits were performed using spreadsheet based engineering calculations.

According to the calculation spreadsheet provided by the site contact, the ex ante kW demand savings for lighting retrofits was calculated as the difference in total power for each grouping of fixtures and fixture locations. The equation for the difference in total power for each lighting group is shown below:

$$kW\ savings_{group} = \left[input\ power\ (W)_{existing} - input\ power\ (W)_{proposed}\right] \times \frac{\#_{fixtures\ in\ group}}{1000\frac{W}{kW}}$$

Demand savings were calculated from the sum of the kW savings from all lighting groups. The ex ante kWh electrical energy savings calculations multiply the kW savings for each group by the annual operating hours for each lighting group to produce annual kWh savings values. The equation for the annual kWh electrical energy savings for each lighting group is show below:

$$Annual\ kWh\ savings_{group} = kW\ savings_{group} \times hours_{annual\ for\ group}$$

Total kWh electrical energy savings was then calculated from the sum of the kWh savings from all lighting groups.

For lighting control measures such as lighting occupancy sensors and daylight harvesting sensors, annual kWh savings were calculated as the total power input for the proposed fixture, in kW, multiplied by an assumed 20 percent reduction in annual operating hours for the lighting group for which the retrofit controls. The equation for the annual kWh electrical energy savings for each lighting control is show below:

$$Annual\ kWh\ savings_{control} = kW\ input_{group} \times 20\% \times hours_{annual\ for\ group}$$

Where,

$$kW\ input_{group} = \frac{input\ power\ (W)_{proposed}}{1000\frac{W}{kW}} \times \#_{fixtures\ in\ group}$$

Measure 3: Vending Machine Controls

No retraceable calculation method was presented in the savings spreadsheet provided that listed the vending control measure description and annual kWh savings. The annual energy savings value for the two planned vending machine controls was 1,612 kWh.

Project Evaluation

A DNV KEMA field engineer visited the project sites on May 23, 2012 to verify the measure installations and gather data on equipment model numbers, quantities, and control schemes. Table 203 summarizes the results of the installation verification.

Table 203: Verification Summary

Site	Equipment	Reported	Verified Installed	Site Notes
Senior Center	10-ton RTU	2	2	Model Number: 48HCDD12A2A5A0A0A0
Senior Center	7.5-ton RTU	1	1	Model Number: 48HCDD08A2A5A0A0
Senior Center	5-ton RTU	1	1	Model Number: 48HCLA06A2A5A0A0A0
Senior Center	3-ton RTU	1	1	Model Number: 48HCLA04A2A5A0A0A0
City Hall	Lighting Fixtures and Controls	320	217	28 items verified as not installed, , 75 items not in verification sample, 9 items differed in quantity or type
City Yard	Lighting Fixtures and Controls	34	0	Not in verification sample
Community Center	Lighting Fixtures and Controls	174	72	15 items verified not installed, 87 items not in verification sampled, 34 differed in quantity or type
Mini Center	Lighting Fixtures and Controls	124	0	Not in verification sample
New Temple	Lighting Fixtures and Controls	32	32	
Old Yard	Lighting Fixtures and Controls	6	0	Not in verification sample
Overpass	Lighting Fixtures and Controls	26	26	
Senior Center	Lighting Fixtures and Controls	179	108	4 items verified not installed, 64 items not in verification sample, 3 items differed in quantity or type
Shively Park	Lighting Fixtures and Controls	18	14	4 items verified not installed
Community Center	Vending Machine Controls	2	0	Vending machine controls not installed. Site contact reported that problems were encountered when they attempted to install the motion sensors.

Source: DNV KEMA analysis

Measure 1: RTU HVAC Systems

The ex post HVAC measure savings analysis was based upon a five-degree (˚F), weather bin analysis spreadsheet method utilizing the local typical meteorological year (TMY3) weather data set, operating schedules and set point temperatures to derive heating and cooling loads. The bin analysis assumed the following: the HVAC equipment is properly sized to meet heating and cooling loads of buildings and the heating and cooling loads are ambient-temperature driven and have a near-linear relationship with ambient temperature.

During the site visit, DNV KEMA verified the installations of the HVAC equipment, acquired model numbers and capacity nameplate information, and gathered operational schedules and set point temperatures from the site contact. Subsequently, DNV KEMA determined heating and cooling efficiency values for the RTUs from manufacturer literature and gathered TMY3 hourly, ambient dry-bulb temperature data from the nearby Burbank-Glendale airport.

As per the set point temperature information provided by the site contact, the building cooling load occurs between the 65-70°F ambient temperature bin and the 105-110°F bin; the building heating load occurs between the ≤30°F bin and the 60-65°F bin. The bin analysis model considers the hours of operation along with flags set to indicate heating and cooling (May – October) months.

The HVAC systems operate weekdays from 7 a.m. to 6 p.m. and Saturdays from 7 a.m. to 2 p.m. Cooling and heating set point temperatures for all of the RTUs are 72 and 66, respectively.

In regards to cooling for Baseline 1, all SEER/ EER values for existing units were reduced by 10 percent from the value listed in the project description to account for age-related performance degradation. For Baseline 2, all replacement RTUs were calculated against the code minimum of 11 EER.

In regards to heating for Baseline 1, all replacement units were compared against their AFUE value listed in the proceeding project description section. For Baseline 2, all replacement RTUs were compared against the minimum 78 AFUE.

This analysis yielded the first-year annual energy savings of 8,343 kWh and 46 therms.

Electric demand savings for the cooling equipment were calculated at full-load cooling capacity by taking the difference between the energy consumption of the high-efficiency replacement units and that of the existing units (for Baseline 1 conditions) or that of normal-efficiency replacement units (for the Baseline 2 conditions). The first-year electric demand savings yielded by this analysis was 12.70 kW for all the units under Baseline 1 conditions.

Measure 2: Lighting Fixtures and Controls

During the on-site visit, DNV KEMA sampled 521 lighting fixtures and controls of the total 911 lighting retrofits performed. This sample represents 58.5 percent of the total ex ante Measure 2 annual kWh savings. Of the lighting that was sampled, DNV KEMA found 49 fixtures or controls that were not installed and 46 fixtures that had different quantities or fixture characteristics. The total claimed annual kWh savings for the fixtures not installed equals 9,193 kWh and total claimed demand savings for these fixtures is 1.94 kW. The findings of the sampling verification are shown below, which reduced fixture quantities by the number of units that were found to not be installed and accounted for changes due to fixtures that had differing quantities or characteristic from the planned retrofits.

- City Hall
  - 17 daylight harvesting lighting controls
  - Two occupancy sensor lighting controls

  - Two exit sign retrofit from incandescent to LED lighting
  - Nine parking lot light retrofits from HPS to induction lighting
  - One rooftop security light retrofit from mercury vapor to induction lighting
  - 14 parking lot light retrofits from mercury vapor to induction lighting
  - 3 parking lot light retrofits from MH to induction lighting
  - 1 4′ 1-lamp T12 to T8 retrofit
  - 24 4′ 1-lamp T8 to T8 (new gen) retrofits
  - 199 4′ 2-lamp T8 to T8 (new gen) retrofits
  - 20 4′ 6-lamp T8 to T8 (new gen) retrofits
- City Yard
  - 34 4′ 2-lamp T8 to T8 (new gen) retrofits
- Community Center
  - 6 daylight harvesting lighting controls
  - 8 exterior fixture retrofits from HPS to induction lighting
  - 9 exterior fixture retrofits from incandescent to CFL lighting
  - 25 parking lot light retrofits from MH to induction lighting
  - 65 4′ 2-lamp T8 to T8 (new gen) retrofits
  - 22 4′ 3-lamp lamp T8 to T8 (new gen) retrofits
  - 18 4′ 4-lamp T8 to T8 (new gen) retrofits
  - 6 2′ 2 U-lamp to U-lamp (new gen) retrofits
- Mini Center
  - 25 4′ 2-lamp lamp T8 to T8 (new gen) retrofits
  - 99 4′ 4-lamp lamp T8 to T8 (new gen) retrofits
- New Temple park
  - 2 exterior fixture retrofits from HPS to induction lighting
  - 26 interior fixture retrofits from incandescent to CFL lighting
  - 4 exterior fixture retrofits from MH to induction lighting
- Old Yard
  - 6 fixture retrofits from MH to induction lighting
- California State Route 60 Overpass
  - 26 exterior 4′ 1-lamp retrofits from T12 to T8 lighting
- Senior Center
  - 10 daylight harvesting lighting controls
  - 6 exterior fixture retrofits from halogen to BR40 flood CFL lighting
  - 8 exterior fixture retrofits from HPS to induction lighting
  - 4 exterior fixture retrofits from incandescent to CFL lighting
  - 3 exterior fixture retrofits from MH to induction lighting
  - 2 4′ 2-lamp retrofits from T12 to T8 lighting

- 106 4′ 2-lamp retrofits from T8 to T8 (new gen) lighting
- 35 4′ 4-lamp T8 to T8 (new gen) retrofits
- 1 2 U-lamp to U-lamp (new gen) retrofits

- Shively Park
  - 10 interior fixture retrofits from incandescent to CFL lighting
  - 4 playground and parking lot fixture from MH to induction lighting

Total annual kWh savings and kW demand savings for each facility, excluding fixtures/ controls that were verified as not installed while including modification to fixture quantities and types, are presented below in Table 204.

Table 204: Ex Post Measure 2 Annual kWh and kW Savings

Facility	Total Electric Savings, kWh/yr	Total Demand Savings, kW
City Hall	38,907	10.40
City Yard	2,246	0.83
Community Center	26,901	6.79
Mini Center	7,968	2.95
New Temple	4,396	1.45
Old Yard	7,096	1.62
Overpass	1,708	0.39
Senior Center	17,135	4.92
Shively Park	5,479	1.31
Grand Total	111,836	30.66

Source: DNV KEMA analysis

This analysis yielded the first-year annual energy savings of 111,836 kWh and 30.66 kW.

Measure 3: Vending Machine Controls

The on-site visit revealed that the vending machine control measures were not completed because of an issue with installation of the motion sensors. As a result, no savings are realized through this measure.

Savings Results and Discussion

The project saved 120,179 kWh of electric energy and 46 therms of natural gas energy in the first year and represents a realization rate of 93.3 percent for electric energy and 17.9 percent for therms energy when compared to the ex ante estimated savings. Furthermore, the project reduced summer on-peak demand by 43.36 kW in the first year.

Measure 1: RTU HVAC Systems

Sources of uncertainty regarding these HVAC calculations included the assumed level of degradation of the existing equipment, reliance on billing data to calibrate pre-retrofit modeled energy use, and the assumptions inherent in the bin analysis method regarding equipment sizing and building cooling and heating loads being primarily weather dependent.

DNV KEMA's higher estimate of savings for electric energy kWh (111.8 percent realization rate) was primarily due to the fact that the ex ante savings calculations were based on assumptions that underestimated the efficiency gain of the replacement equipment and the existing air-conditioning energy consumption. These factors were:

- Replacement units had a higher SEER value (~15) than was initially planned (14 SEER)
- The assumed overall cooling load factor of 4.3 percent (25 percent of 1,507 annual operating hours) was lower than the ex post calculated overall cooling load factor of 7.5 percent.

DNV KEMA's lower savings estimate for natural gas energy (17.9 percent realization rate) was primarily due to the ex ante calculations' more than calculation of the total heating capacity of the facility as well as the difference in overall heating load factor between ex ante estimates and ex post calculations. The ex ante calculation method assumed the heating capacity was 20,000 times the total cooling capacity tons, which yielded a total heating capacity of 710 kBTU/hr, while the actual installed heating capacity is 351 kBTU/hr (based on nameplate heating capacity). Further compounding the overestimation of therm savings was the assumed ex ante overall heating load factor of 3.4 percent compared to the ex post calculated overall heating capacity factor of 1.2 percent.

DNV KEMA's higher ex post savings estimate for demand reduction (104.7 percent) was due to the fact that the ex ante calculation method underestimated the efficiency gain of the replacement equipment.

Measure 2: Lighting Fixtures and Controls

Sources of uncertainty regarding these calculations were as follows:

- The installation verification sample was only 57.3 percent of the total claimed installations
- The assumptions regarding operating hours for the fixtures and occupancy sensor control retrofits

DNV KEMA's lower ex post savings estimate was primarily due to the 49 claimed installations that were not installed, which accounted for 9,193 kWh of claimed ex ante savings. The remaining 527 kWh shortfall was a result of the 46 installations that varied from what was reported in the ex ante calculation.

Measure 3: Vending Machine Controls

As this measure was not installed, no savings were realized.

Ex Post Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

Table 205 displays the first year savings used to calculate the Baseline 1 and Baseline 2 life-cycle savings. Table 205 also lists the effective and remaining useful lives of each measure. A RUL of one year was used for the existing RTUs as they were beyond their EUL, but the site contact reported them still fully functional. Based upon the current age of the existing equipment—seven years—and an EUL of 15 years, a RUL of eight years was used for the existing lighting equipment. Table 206 presents the electrical energy, electrical demand, and natural gas energy savings according to Baseline 1 conditions for each year the measure is in place up to the end of the measure's EUL. Table 206 presents the yearly life-cycle savings values according to Baseline 2 conditions.

Table 205: Values Used in Ex Post Life-cycle Savings Calculations

Measure	Early Replacement			Expected Replacement			EUL (years)	RUL (years)
	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)		
RTUs	8,343	12.70	46	1,758	2.66	36	15	1
Lighting Interior/ Exterior	111,836	30.66	0.0	111,836	30.66	0.0	15	8
Vending Machine Controls	0.0	0.00	0.0	0.0	0.00	0.0	15	N/A
Total	120,179	43.36	46	113,594	33.32	36	-	-

Source: DNV KEMA analysis

Table 206: Baseline 1 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	120,179	43.36	46.00
2	2013	120,179	43.36	46.00
3	2014	120,179	43.36	46.00
4	2015	120,179	43.36	46.00
5	2016	120,179	43.36	46.00
6	2017	120,179	43.36	46.00
7	2018	120,179	43.36	46.00
8	2019	120,179	43.36	46.00
9	2020	120,179	43.36	46.00
10	2021	120,179	43.36	46.00
11	2022	120,179	43.36	46.00
12	2023	120,179	43.36	46.00
13	2024	120,179	43.36	46.00
14	2025	120,179	43.36	46.00
15	2026	120,179	43.36	46.00
Life-cycle	Total	1,802,685 kWh	650.4 kW-years	690 Therms

Source: DNV KEMA analysis

Table 207: Baseline 2 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	120,179	43.36	46.00
2	2013	113,594	33.32	36.00
3	2014	113,594	33.32	36.00
4	2015	113,594	33.32	36.00
5	2016	113,594	33.32	36.00
6	2017	113,594	33.32	36.00
7	2018	113,594	33.32	36.00
8	2019	113,594	33.32	36.00
9	2020	113,594	33.32	36.00
10	2021	113,594	33.32	36.00
11	2022	113,594	33.32	36.00
12	2023	113,594	33.32	36.00
13	2024	113,594	33.32	36.00
14	2025	113,594	33.32	36.00
15	2026	113,594	33.32	36.00

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
Life-cycle Total		1,710,495 kWh	509.8 kW-years	550 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Clearlake, City of (CBG-09-169)

Site Summary

The project at the Clearlake facilities consisted of four measures including a lighting upgrade and a cool-roof installation at the combined city hall/police department building, a lighting upgrade at the community center, and new LED traffic signals and induction street lights throughout the city. Typical operating hours for the city hall are 6:30 a.m. to 6 p.m. Monday through Friday with limited operation on weekends for cleaning services, and the police department operates 24 hours per day. The community center is open Monday through Friday 8 a.m. to 5 p.m.

The implemented measures at the Clearlake facilities include three lighting measures – indoor fixtures (EEM1), exterior fixtures (EEM2), and LED traffic signals (EEM3) – and one cool-roof measure (EEM4). Table 208 summarizes the ex post and ex ante savings estimates for this project.

Table 208: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 – Retrofit indoor light fixtures	13,260	None claimed	0.0	12,837	2.58	0.0	97%	N/A
EEM2 – Retrofit exterior light fixtures	24,725	None claimed	0.0	24,725	0.0		100%	
EEM3 – Retrofit traffic signals to LED units	13,460	None claimed	0.0	13,460	1.54		100%	
EEM4 – Install cool roof on city hall building	79,184	None claimed	-920	36,700		-857	46%	N/A
Total	130,629		-920	87,722	4.12	-857	67%	N/A

Source: DNV KEMA analysis

For EEM1, the evaluation team performed a complete lighting survey of the city hall building and installed light loggers throughout all major space types. The program savings calculations

did not include annual hours of operation or light fixture quantities. As such, it is difficult to determine if the difference in calculated savings is due to a discrepancy in the quantity of fixtures installed or in the assumed annual hours of operation.

For EEM2 and EEM3, the evaluation team completed a full lighting survey of all units installed as part of this measure. All fixture quantity counts and fixture types were verified during the site inspection. No adjustments were made to the annual savings calculations.

For EEM4, the evaluation team verified the installation of the cool roof on the city hall/police department building. The total area of the roof was measured on-site and verified using satellite images to be 23,900 square feet, not 22,000 square feet as listed in the program documents. The ENERGY STAR® calculation tool used as the basis for the ex ante savings calculations is no longer available and is in the process of being replaced with a new tool. The evaluation team used the Department of Energy (DOE) Cool Roof Calculator, Version 1.2 to estimate ex post savings.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

The baselines were identical for all four measures.

The DEER EUL for the indoor lighting retrofits (EEM1), outdoor lighting retrofits (EEM2), and cool-roof installations (EEM4), was 15 years. DEER does not provide a EUL value for LED traffic signals; however the DOE and Vermont Energy Investment Corporation studies both list the EUL at 10 years. Table 209 provides a life-cycle saving summary.

Table 209: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baselines 1 & 2	1,248,584	4.12	-12,855

Source: DNV KEMA analysis

Project Description

This project involved the retrofit of indoor fixtures, outdoor fixtures, and traffic signals and the installation of a cool roof in the city of Clearlake. The following areas were included in the

retrofit: the city hall/police department building, public parks, and the community/senior center.

Measure 1 – Retrofit Indoor Light Fixtures

EEM1 consisted of a complete lighting retrofit in the joint city hall/police department building as well as the senior/community center. The savings calculations provided to the evaluation team for this measure contained neither the quantities of fixtures replaced nor the assumed annual hours of operation. Site contacts confirmed the baseline fixture technologies for each space and site inspections verified that 28 watt (W) T8 fixtures were installed throughout both buildings. The lighting contractor did not provide the site with a comprehensive lighting audit. The vast majority of the line items involve the relamping of standard ballast factor 32 W T8 fixtures with 28 W T8 lamps.

No savings algorithm was included with the calculations submitted in the program documentation. Savings were listed for each building and major fixture type; however these line-by-line savings figures did not include fixture quantities or assumed annual hours of operation.

HVAC interactive effects were not accounted for in the ex ante savings estimates and therefore they are not included in the ex post analysis.

Measure 2 – Retrofit Exterior Light Fixtures

EEM2 consisted of a lighting retrofit of the exterior lights in two city parks as well as the parking lots of both the city hall/police department and community/senior center. The savings calculations provided to the evaluation team for this measure contained pre and post fixture types as well as quantities and annual hours of operation. Site contacts confirmed the baseline fixture technologies for each of the exterior fixtures observed.

Savings were calculated line-by-line using the following algorithm:

$$Annual\ savings\ (kWh) = [BFW \times BFQ] \times BaseRunHrs - [RFW\ \times\ RFQ]\ \times\ PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
$BaseRunHrs$	= Pre-retrofit annual hours of operation for usage group
$PostRunHrs$	= Postretrofit annual hours of operation for usage group (assumed to be the same as none of the measures involved the installation of occupancy sensors)

Measure 3 – Retrofit Traffic Signals to LED Units

EEM3 consisted of retrofitting 35 existing incandescent traffic signals with new LED bulb units. The savings calculations provided to the evaluation team for this measure contained pre and post traffic signal sizes, wattages, quantities, and annual hours of operation. Site contacts confirmed the baseline fixture technologies for the traffic signals observed.

Measure 4 – Install Cool Roof on City Hall/Police Department Building

EEM4 consisted of installing a new cool roof membrane on the city hall/police department building. The new highly reflective roof will reduce the summer cooling load on the existing roof-mounted packaged HVAC units. Savings for this measure were calculated using the ENERGY STAR Roofing Calculator V1.0. The tool uses a standard weather file based on zip code as well as information about the HVAC system type, age, pre and post roofing materials, and roof insulation to determine annual electric savings and heating penalties for the measure.

Project Evaluation

An ERS engineer visited the facility on February 15, 2012 to verify the installation of each measure and the hours of operation with site staff, ensure that the equipment specifications met those listed in the program documentation, and deploy indoor light fixture metering equipment. The evaluation team deployed light loggers covering five space types, inspected the remaining measures installed as part of this project, and verified the equipment counts and specifications.

Measure 1 – Retrofit Indoor Light Fixtures

The savings calculations provided to the evaluation team for this measure contained neither the quantities of fixtures replaced nor the assumed annual hours of operation. In addition, the lighting contractor did not provide the site with a comprehensive lighting audit detailing the spaces were fixtures had been replaced. As such the evaluation team completed a comprehensive room-by-room lighting survey and deployed five light loggers to monitor the usage patterns of all major space types. In addition, for each fixture type the evaluation team verified that the lamps and ballasts installed matched those listed in the lighting survey.

ERS verified the installation of 211 fixtures in 17 spaces. Light loggers were deployed in five major space types, which encompassed the usage patterns of 121 of the 211 fixtures. Light loggers were deployed for three weeks to record standard operating procedures. Three spaces were monitored in city hall, one area was monitored in the police department, and one area was monitored in the senior center. Figure 86 below summarizes the logged data averaged by weekday. The logged hours of operation were used to calculate annual hours of operation.

Figure 86: Sample Light Fixture Logger Data

Average of City Manager - Open Office Front								
	Weekday (Sunday = 1)							
Hour	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**Average**
0	3%	0%	0%	0%	1%	0%	9%	2%
1	9%	0%	0%	0%	4%	0%	0%	2%
2	0%	0%	0%	0%	7%	12%	0%	3%
3	11%	3%	0%	0%	22%	11%	0%	8%
4	4%	13%	0%	2%	12%	0%	0%	5%
5	9%	2%	0%	5%	7%	13%	0%	5%
6	10%	27%	42%	38%	31%	28%	6%	24%
7	8%	51%	90%	97%	96%	86%	2%	58%
8	4%	69%	100%	100%	100%	99%	3%	65%
9	0%	69%	97%	100%	100%	99%	8%	64%
10	0%	89%	100%	100%	98%	93%	6%	66%
11	6%	91%	100%	100%	99%	93%	0%	68%
12	0%	70%	85%	99%	100%	83%	0%	61%
13	0%	99%	100%	98%	100%	98%	8%	70%
14	0%	88%	100%	99%	99%	99%	24%	71%
15	14%	90%	98%	100%	89%	99%	1%	69%
16	13%	71%	100%	92%	97%	96%	4%	66%
17	0%	60%	100%	89%	84%	73%	6%	57%
18	0%	37%	52%	50%	18%	9%	8%	23%
19	0%	18%	23%	26%	3%	9%	2%	11%
20	4%	3%	7%	17%	11%	8%	6%	8%
21	0%	13%	17%	6%	9%	0%	8%	7%
22	10%	0%	27%	2%	0%	0%	4%	5%
23	0%	0%	8%	6%	7%	2%	14%	5%
Average	**4%**	**40%**	**52%**	**53%**	**50%**	**46%**	**5%**	**35%**

Source: DNV KEMA analysis

Savings were calculated line-by-line using the following algorithm:

$$\textit{Annual savings (kWh)} = [BFW \times BFQ] \times BaseRunHrs - [RFW \times RFQ] \times PostRunHrs$$

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Pre-retrofit annual hours of operation for usage group
PostRunHrs	= Post-retrofit annual hours of operation for usage group (assumed to be the same except for one group, which involved the installation of occupancy sensors)

Figure 87 and Figure 88 below show sample light fixtures and ballasts surveyed as part of the inspection process.

Figure 87: Senior Center – Exercise Room Fixtures

Photo Credit: DNV KEMA analysis

Figure 88: City Hall – 28 W Lamps

Photo Credit: DNV KEMA

Measure 2 – Retrofit Outdoor Light Fixtures

On-site verification activities confirmed that the installed fixtures and quantities matched the savings calculations included in the program documentation. At each location the evaluation team verified that the lamps matched those listed in the lighting survey. Annual hours of operation were listed at 4380 hours per year, which is entirely reasonable for exterior fixtures.

Measure 3 – Retrofit Traffic Signals to LED Units

On-site verification activities confirmed that the traffic signals were retrofitted to LED units and that the quantities matched the savings calculations included in the program documentation.

Measure 4 – Install Cool Roof on City Hall Building

On-site verification activities included confirming the installation of the roof as well as all major inputs to the savings calculation tool such as HVAC system specifications, roof insulation, and total roof area. The original calculations provided to the evaluation team were computed using the ENERGY STAR Roofing Calculator V1.0. This online tool is no longer supported or available to replicate the original calculations. The savings calculations assumed that the building had a total baseline roof insulation level of R-0. During the site inspection it was clear that the roof was originally insulated, although site contacts did not know the details of the insulation level.

Since the building is more than 30 years old the evaluation team assumed a roof insulation level of R-5, based on an asphalt shingle roof. In addition, during the site inspection, the evaluation team measured the total roof area and found it to be 23,800 square feet, 1,800 square feet larger than indicated in the program documentation. These two changes were incorporated into the new DOE Roofing Calculator V1.2 to calculate annual savings. Other key calculator inputs include: roof area - 23,900 square feet; solar reflectance - 90; infrared emittance - 80, and; location-Sacramento.

Savings Results

Taking into account all four energy efficiency measures (EEMs), the Clearlake project resulted in 87,722 kWh in annual gross energy savings. Peak demand savings of 4.12 kW were estimated using coincident demand factors from DEER 2011 and metered data from the light loggers. The savings calculations included in the program documentation did not contain any demand savings calculations. A breakdown of savings by individual measure is presented in Table 208 at the beginning of this report. The ex ante savings estimates, which were acquired from the program's monthly status reports, are also provided as a point of reference.

Discussion

Measure 1 - Retrofit Indoor Light Fixtures

On-site verification activities confirmed that the lighting measure was installed in the buildings listed in the program documentation and that the baseline and installed technologies match those listed in the savings calculations. The evaluation team surveyed the installation of 210 fixtures in 17 spaces while conducting a complete lighting survey. Five light loggers were deployed for three weeks to determine usage patterns and annual hours of operation. Logged spaces contained 131 of the total fixtures encompassed in the retrofit. Total savings for this

measure were only 88.4 percent of the ex ante savings estimates. It is difficult to determine where the discrepancy in the savings occurred as the program documents do not list fixture counts or hours of operation for the lighting groups.

Measure 2 – Retrofit Outdoor Light Fixtures

On-site verification activities confirmed that the lighting measure was installed as detailed in the ex ante savings calculations. The evaluation team verified the inputs of the savings calculations and found them to accurately reflect the installed system.

Measure 2 – Retrofit Traffic Signals to LED Units

On-site verification activities confirmed that the lighting measure was installed as detailed in the ex ante savings calculations. The evaluation team verified the inputs of the savings calculations and found them to accurately reflect the installed system.

Measure 4 – Install Cool Roof on City Hall Building

The original calculations provided to the evaluation team were computed using the ENERGY STAR Roofing Calculator V1.0, which is no longer available to the public or supported by the DOE. On-site verification activities determined that the roof insulation value and total roof area needed to be changed in order to more accurately determine annual savings. Since the ENERGY STAR Roofing Calculator V1.0 was not available, savings were recalculated using the updated DOE Roofing Calculator V1.2. Total savings for this measure were only 46 percent of the ex ante savings estimates. The reduction in savings is a result of the model inputs, most importantly the change from R-0 roof insulation to R-5 roof insulation and the use of Sacramento as the site location (the most comparable site location available in the model).

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1), which considers the existing conditions found prior to the EEM implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 210 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 210: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	87,722	4.12	-857
2	2012	87,722	4.12	-857
3	2013	87,722	4.12	-857
4	2014	87,722	4.12	-857
5	2015	87,722	4.12	-857
6	2016	87,722	4.12	-857
7	2017	87,722	4.12	-857
8	2018	87,722	4.12	-857

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
9	2019	87,722	4.12	-857
10	2020	87,722	4.12	-857
11	2021	74,262	2.58	-857
12	2022	74,262	2.58	-857
13	2023	74,262	2.58	-857
14	2024	74,262	2.58	-857
15	2025	74,262	2.58	-857
Total		1,248,584 kWh		-12,855 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Sierra Madre, City of (CBG-09-171)

Site Summary

The city of Sierra Madre completed a lighting retrofit and lighting controls project that affected five buildings. Sierra Madre also planned to replace four packaged HVAC units, but ultimately amended their contract to remove this measure. Table 211 below summarizes the energy savings achieved by the lighting retrofit project.

Table 211: Energy Savings Summary

Measure	Ex Ante		Ex Post (Baseline 1)		Realization Rate	
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)	Electric	Gas
Lighting Retrofit	54,914	0.0	31,696	0.0	58%	N/A
Lighting Controls	8,596	0.0	8,571	0.0	100%	N/A
Total	63,510	0.0	40,267	0.0	63%	N/A

Source: DNV KEMA analysis

Life-cycle savings were calculated for each EEM based on DEER EUL values. Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment is exceeded

Table 212: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Natural Gas Energy Savings (Therms)
Baseline 1	544,008 kWh	0.0 Therms
Baseline 2	544,008 kWh	0.0 Therms

Source: DNV KEMA analysis

Project Description

The city of Sierra Madre completed comprehensive lighting retrofits in three buildings: City Hall, the Police & Fire Station, and the Public Works (PW) Yards. The retrofit additionally affected select areas of the City Library and Recreation Center. The largest component of the project consisted of replacing magnetic ballast T12 fixtures with electronic ballast T8 fixtures. Many incandescent lamps were also replaced with HPS or CFL lamps. All fixtures were replaced on a one-to-one basis. Figure 89 below summarizes the pre and postretrofit lighting fixtures.

Figure 89: Fixture Retrofit Summary

Existing Fixtures		Installed Fixtures	
Fixture Type	**Count**	**Fixture Type**	**Count**
1-F40T12 Magnetic	31	1-F32T8	31
1-F72T12 Magnetic	7	1-F72T8	7
1-F96T12 Magnetic	19	1-F96T8	1
2-F40T12 Magnetic	68	2-F32T8	91
2-F40T12-U Magnetic	12	2-F32T8-U	12
2-F96T12 Magnetic	9	2-F96T8	9
2-F96T12-HO Magnetic	11	2-PL-13W	1
3-F20T12 Magnetic	4	3-F32T8	65
3-F40T12 Magnetic	61	4-F32T8	78
4-F40T12 Magnetic	71	4-F96T8	2
4-F96T12 Magnetic	2	HI-75W	31
INC-100W	58	HPS-35W	6
INC-150W	2	PL-13W	13
INC-2-100W Magnetic	1	SI-26W	9
Total	**356**	**Total**	**356**

Source: DNV KEMA analysis

In addition to retrofitting existing fixtures, the city installed 38 occupancy sensors, 12 photo sensors, and 4 timer controls in locations throughout each of the affected buildings.

Ex Ante Savings

Ex ante savings calculations were not provided for review. The available feasibility study report included tables listing the projected savings, but did not indicate how the claimed savings were derived. The site contact provided documentation listing the lighting usage hours, but it is unclear if the same operating hour estimates were used in the feasibility study savings calculation.

Project Evaluation

Prior to the site visit, the city contact provided a project scope document listing the final claimed fixture and occupancy sensors installations. Since the scope of the project was limited

to less than 400 fixtures across five buildings, a complete census of the project was completed during the site visit.

Before verifying fixture and sensor installation, the site contact was interviewed to obtain revised operating hour estimates for each of the areas affected by the retrofit lights and new sensors. All proposed fixtures and controls were then verified. During the facility walkthroughs, one critical discrepancy between the claimed scope and the actual scope was noted. In each location that 4' T8 fixtures were listed, the scope document indicated that 28W lamps were installed (consistent with the feasibility study). In reality, 32W lamps were installed in all cases. Since 277 of the 356 affected fixtures were 4' T8 fixtures, the impact of this lamp substitution was substantial. Few other discrepancies between the scope document and the installed scope were identified. While the document indicated that 353 fixtures were retrofitted, a total of 356 retrofitted fixtures were identified on-site. Other minor discrepancies in fixture types or counts were noted in a few locations, but the project was otherwise well documented. Lastly, occupants delamped 14 of the retrofitted fixtures after the fact because of lighting level preferences. Savings resulting from delamping were included in the subsequent savings analysis.

Following the site visit, savings were calculated based on the revised fixture schedule, fixture counts, and operating hour data. For each group of retrofit fixtures, savings were calculated according to the following formula:

$$kWh_{saved} = \frac{n_{fixt}(W_{pre}h_{op} - W_{post}h_{op}f_c)}{1000}$$

Where,

kWh_{saved}	= Lighting energy savings (kWh)
n_{fixt}	= Number of fixtures in a given lighting group
W_{pre}	= Pre-existing fixture wattage (W)
W_{post}	= Postretrofit fixture wattage (W)
h_{op}	= Fixture group operating hours
f_c	= Postretrofit lighting control operating hour scale factor
1000	= Watt to kilowatt conversion factor (W/kW)

The postretrofit operating hour scale factor, f_c, was set to 70 percent for occupancy sensor and auto-shutoff timer controlled fixtures. For photocell controlled fixtures, f_c was set to 90 percent and 50 percent for exterior fixtures and interior fixtures respectively. All exterior lights were previously on timer controls, meaning the newly installed photocell controls only save energy to the extent that they improve upon city's pre-existing schedules, which were unavailable for review. A 10 percent improvement (hence a factor of 90 percent) was estimated. The interior photocell controls, which were only installed in one location, substantially reduce the usage of fixtures that previously operated 16 hours per day. The installed sensors were liberally

estimated to reduce the operating hours of those fixtures by eight hours per day, or 50 percent. Postretrofit fixture wattages were adjusted as necessary to account for delamping.

Savings Results

Relative to the pre-existing lighting (Baseline 1), the project saved a total of 40,267 kWh, yielding a 63 percent realization rate. Since only the lamps and ballasts were replaced as opposed to the entire fixtures, Title 24 was not triggered for the Baseline 2 calculation. Instead, the city would have been able to replace the existing lamps and ballasts with identical components in the absence of the EECBG. Furthermore, lighting controls would not have been implemented in the absence of the program. As such, the pre-existing equipment served as the baseline for the expected replacement calculation, resulting in identical savings of 40,267 kWh and a realization rate of 63 percent relative to Baseline 2.

Discussion

A full explanation for the discrepancy between the ex post savings and the ex ante savings is not possible since the savings calculations used to derive the ex ante savings were not provided. However, by installing 32W T8 lamps instead of 28W T8 lamps in 277 fixtures, the project's savings potential was reduced by roughly 8,000 kWh to 10,000 kWh. This change alone decreased the project's realization rate from nearly 80 percent to 63 percent.

Other unverifiable changes in project scope and adjustments to the projected lighting operating hours are most likely responsible for the remaining reduction in savings.

Life-cycle Savings

Table 213 below provides the annual energy savings estimates that fed into the life-cycle savings calculations, as well as the EULs for the installed measures.

Table 213: Values Used in Life-cycle Savings Calculations

Measure	Early Replacement		Expected Replacement		EUL (years)	RUL (years)
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)		
Lighting retrofit	31,696	0.0	31,696	0.0	15	0
Lighting Controls	8,571	0.0	8,571	0.0	8	0

Source: DNV KEMA analysis

Table 214 provides life-cycle savings for the project relative to Baseline 1 and Baseline 2.

Table 214: Life-cycle Savings Relative to Baseline 1 and Baseline 2

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Natural Gas Energy Savings (Therms/yr)
1	2011	40,267	-
2	2012	40,267	-
3	2013	40,267	-
4	2014	40,267	-
5	2015	40,267	-
6	2016	40,267	-
7	2017	40,267	-
8	2018	40,267	-
9	2019	31,696	-
10	2020	31,696	-
11	2021	31,696	-
12	2022	31,696	-
13	2023	31,696	-
14	2024	31,696	-
15	2025	31,696	-
16	2026	-	-
Life-cycle	Total	544,008 kWh	0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Los Gatos, Town of (CBG-09-184-A)

Site Summary

The City of Los Gatos was awarded funds to retrofit a number of outdoor lighting fixtures throughout various city locations. The project replaced HPS fixtures with induction type fixtures.

Ex post energy savings were estimated at 73,964 kWh which represent 112 percent of the ex ante estimates (Table 215). The higher energy savings rate is due to changes in scope that were not yet accounted for in the ex ante calculations; the final project was for the retrofit of 223 fixtures versus the original 193. To a smaller extent, ex post energy savings were higher also because of revisions made to the hours of operation. The lighting hours of operation were revised from 4100 to 4309 hours per year because the fixtures were on photocell controls.

Table 215: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
Exterior Lighting	65,990[38]	0.0	0	73,964	0.0	0	112%	N/A

Source: DNV KEMA analysis

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment is exceeded

The overall results from Table 215 yield a life-cycle energy savings of 1,183,424 kWh for both baselines 1 and 2 (Table 216). Baselines 1 and 2 are the same because no additional code requirements apply for fixture retrofits. Life-cycle savings were calculated relative to the pre-existing condition for the full EUL of the fixtures.

38 Values taken from "EEP_andDEP 012012.xlsx" file as of 9/17/2012.

Table 216: Life-cycle Savings Summary

Life-cycle	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1	1,183,424	0	0
Baseline 2	1,183,424	0	0

Source: DNV KEMA analysis

Project Description

In the initial application, 193 fixtures were to be retrofitted with a combination of induction and LED fixtures. There was also three other measures that would have affected the air-conditioning at the city library. However, a letter of agreement was done to eliminate the HVAC, VFDs and motors. The light costs were much higher than the original grant estimate; and the Town could not afford to install the HVAC, VFDs and motors. Therefore, funding was reallocated funds helped pay for the higher cost of lights as well as funding an additional 17 LED lights for the new location of Civic Center Pathway.

At the time of the evaluation, a total of 223 HPS and MH fixtures were replaced with induction fixtures. These fixtures were located at various city parking lots and park pathways.

Ex Ante Savings

The ex ante savings used standard spreadsheet analysis. The algorithm included pre and post lighting fixture wattages, quantities, and estimates in hours of operation. Energy savings were estimated at 65,990 kWh. Preretrofit fixtures housed 70 to 200 Watt HPS lamps. Postretrofit fixtures included both induction and LED fixtures which housed lamps ranging from 40 to 150 Watts. The algorithm used 4100 hours as the total annual hours of operation for all of the exterior lights.

Project Evaluation

A DNV KEMA field engineer visited the project's sites on March 14th, 2012 to verify measure installation. The measure is straightforward and only verification of the quantities and hours of operation were required for this site.

DNV KEMA obtained an updated spreadsheet from a representative at the City of Los Gatos showing the fixture locations, pre and post wattages, and quantities (Figure 90). This spreadsheet was used to reference each fixture during the site visit.

Figure 90: Updated Table Obtained From Site Contact Showing Lighting Locations, Quantities, Pre Fixture Wattages, and Post Fixture Wattages

	Existing Equipment	Proposed Equipment	Facility Where Equipment Installed	Existing Capacity (kW, HP, Btus, etc.)	Proposed Capacity (kW, HP, Btus, etc.)	Number of Units
1	200 w Metal Halide Shoebox	150 w Induction Shoebox	Los Gatos / Saratoga Long Term Lot	0.236	0.153	22.00
2	150 w HPS Cobra Head	70 w Induction Cobra Head	Lot 1 - Los Gatos / Saratoga / Bantham	0.188	0.071	4.00
3	100 w HPS Cobra Head	70 w Induction Cobra Head	Lot 1 - Los Gatos / Saratoga / Bantham	0.125	0.071	1.00
4	70 w HPS Decorative	40 w Induction Conversion	Lot 2 - Bantham / Royce	0.088	0.041	4.00
5	70 w HPS Shoebox	40 w Induction Shoebox	Lot 3 - Royce / Graves	0.088	0.041	6.00
6	70 w HPS Shoebox	40 w Induction Shoebox	Lot 4	0.088	0.041	21.00
7	4 x 50 w HPS box	2 x 55 w Induction box	Lot 4	0.063	0.056	2.00
8	100 w HPS Wallpack	40 w Induction Wallpack	Lot 4	0.125	0.041	9.00
9	70 w HPS Bollard	55 w Induction Conversion	Lot 4	0.088	0.057	7.00
10	200 w HPS Cobra Head	80 w Induction Cobra Head	Lot 5 - Elm / Main St	0.24	0.082	7.00
11	70 w HPS Cobra Head	80 w Induction Cobra Head	Lot 5 - Elm / Main St	0.088	0.082	3.00
12	70 w HPS Shoebox	40 w Induction Shoebox	Monte Bello Lot	0.088	0.041	5.00
13	70 w HPS Shoebox	40 w Induction Shoebox	Lot 7 - Main St	0.088	0.041	5.00
14	70 w HPS Shoebox	40 w Induction Shoebox	Lot 8 - Main St	0.088	0.041	4.00
15	100 w HPS Wallpack	40 w Induction Wallpack	Corporation Yard	0.125	0.041	9.00
16	200 w HPS Floodlight	100 w Induction Floodlight	Corporation Yard	0.24	0.102	3.00
17	175 w Metal Halide Floodlight	100 w Induction Floodlight	Corporation Yard	0.215	0.102	1.00
18	70 w HPS Decorative	40 w Induction Conversion	Southside Lot, North Santa Cruz	0.088	0.041	6.00
19	200 w HPS Cobra Head	100 w Induction Cobra Head	Balzer Field Lot	0.24	0.102	2.00
20	100 w HPS	40 w Induction	Bachman Path	0.125	0.041	4.00
21	70 w HPS	40 w Induction	Balzer Field	0.088	0.041	1.00
22	100 w flood	40 w Induction Flood	Balzer Field	0.1	0.041	4.00
23	100 w HPS	40 w Induction	Belgatos Path	0.125	0.041	4.00
24	100 w Mercury Vapor	40 w Induction	Belgatos Restroom (Outside)	0.125	0.041	4.00
25	100 w HPS	40 w Induction	Blossom Hill Path Lights	0.125	0.041	13.00
26	70 w HPS	40 w Induction	Blossom Hill Restroom (Outside)	0.088	0.041	4.00
27	70 w HPS	40 w Induction	Forbes Mill Building	0.088	0.041	4.00
28	100 w HPS	40 w Induction	Howes Path	0.125	0.041	4.00
29	100 w HPS	40 w Indutction	La Rinconada Path	0.125	0.041	12.00
30	175 w Mercury Vapor	80 w Induction	Live Oak Manor Path	0.205	0.082	12.00
31	100 w HPS	40 w Induction	Live Oak Manor Gazebo	0.125	0.041	1.00
32	100 w HPS	40 w induction	Oak Hill Playlot	0.125	0.041	2.00
33	100 w HPS	40 w Induction	Oak Meadow Path/Picnic	0.125	0.041	13.00
34	100 w HPS	40 w Induction	Oak Meadow Entrance	0.125	0.041	8.00
35	70 w HPS	40 w Induction	Oak Meadow Booth	0.088	0.041	1.00
36	70 w HPS	40 w Induction	Oak Meadow Restroom	0.088	0.041	4.00
37	100 w HPS	40 w Induction	Town Plaza Path	0.125	0.041	11.00
38	70 w HPS	40 w Induction	Town Plaza Bus Shelter	0.088	0.041	2.00

Source: DNV KEMA analysis

Site findings & Analysis

The lighting was installed as specified with the exception of a few minor differences. The differences are listed here. The line item values mentioned are in reference to Figure 90 above.

- Line item 38 was not retrofitted
- The quantity found for line item 30 is 10 not 12
- For line item 22, there were four 100 Watt flood fixtures that were replaced with two 40 Watt induction flood fixtures.

- The quantities for line item 8 and 9 are in reverse order.

After physical verification of the lighting was completed, DNV KEMA inquired about the hours of operation of the lights pre and postretrofit. The site contact indicated that all exterior lights were on photocell controls. This is true in both the pre and postretrofit conditions.

Energy savings were calculated using pre and postretrofit wattages, quantities, and annual hours of operation. Since the site contact indicated that the lights were controlled via photocells, an analysis using daily sunset and sunrise times for a nearby location were performed. Hours of operation were calculated by determining the total number of hours for each day between sunset and sunrise. The total annual hours of operation was estimated at 4309 using this method and was employed in the energy savings algorithm.

Savings Results

Total energy savings for the measures evaluated at this site are 73,964 kWh. Since the operation occurs during non-peak hours, there are no demand savings. The ex post results are shown with the ex ante estimates in Table 215 for comparison.

Discussion

The energy savings for this project is 112 percent of the ex ante reported value. The ex post algorithm employed a higher value for the hours of operation since the fixtures were controlled via photocells.

Ex Post Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

In the case for the exterior light fixtures, there is no established standard practice so the same base case is used for both calculations. Expected EUL values for outdoor lighting fixtures are 16 years according to a CPUC estimate for induction fixtures.[39] Details of this calculation are shown in Table 217.

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39 CPUC, Energy Efficiency Policy Manual, 2001. http://docs.cpuc.ca.gov/published/Graphics/11474.pdf, accessed 3/13/2012.

Table 217: Values Used in Life-cycle Savings Calculations

Measure	Early Replacement		Expected Replacement		EUL (years)	RUL (years)
	Electric Energy (kWh)	Gas Energy (Therms)	Electric Energy (kWh)	Gas Energy (Therms)		
Exterior Light Fixtures	73,965	0	73,965	0	16	0

Source: DNV KEMA analysis

The life-cycle savings for both Baseline 1 and 2 with an EUL of 16 years is calculated at 1,183,424 kWh. Table 218 below shows the life-cycle savings by year for these measures.

Table 218: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	73,964	0.0	0
2	2012	73,964	0.0	0
3	2013	73,964	0.0	0
4	2014	73,964	0.0	0
5	2015	73,964	0.0	0
6	2016	73,964	0.0	0
7	2017	73,964	0.0	0
8	2018	73,964	0.0	0
9	2019	73,964	0.0	0
10	2020	73,964	0.0	0
11	2021	73,964	0.0	0
12	2022	73,964	0.0	0
13	2023	73,964	0.0	0
14	2024	73,964	0.0	0
15	2025	73,964	0.0	0
16	2026	73,964	0.0	0
17	2027	0	0.0	0
Life-cycle	Total	1,183,424	0.0	0

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Yuba, County of (CBG-09-190-A)

Site Summary

This project involved the relamping or replacement of 3,264 fixtures throughout five Yuba county buildings and the installation of a variable speed drive (VSD) and new motor on a single cooling tower. The following areas were included in the retrofit: Animal Control, Government Center, North Annex, Dan Avenue, and County Courthouse. Typical operating hours for Animal Control, Government Center, North Annex, and Dan Avenue are 7 a.m. to 5p.m., Monday through Friday. The main County Courthouse also contains a jail, so some parts operate 24 hours per day.

The implemented measures at the Yuba County buildings included (EEM1) retrofitting lighting fixtures and (EEM2) install VSDs on cooling tower fans. Table 219 below summarizes the ex post and ex ante savings estimates for each measure.

Table 219: Energy Savings Summary

Measure	Ex Ante[40]			Ex Post			Realization Rate	
	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 – Retrofit indoor light fixtures	261,905	77.5	0	326,742	69.0	0	125%	N/A
EEM2 – Install VSD on cooling tower fan	50,395	0	0	64,439	25.3	0	128%	N/A
Total	312,300	77.5	0	391,181	94.3	0	125%	N/A

Source: DNV KEMA analysis

There is a slight difference between the ex post savings and those estimated in the ex ante calculations. Due to the large number of fixtures, building types, and space types, the evaluation team could not gather statistically significant metered lighting data within the project budget. As such, the evaluation team inspected a portion of the light fixtures installed as

40 It should be noted this table only includes the ex ante savings for those measures completed before April 25, 2012.

part of this project, obtained a revised installed lighting inventory, and reviewed cooling tower VFD analysis assumptions.

Savings for EEM1 were modified after the revised lighting inventory was found to only include five of the nine buildings that were part of the savings calculations included in the program documents. Since the remaining four buildings had not yet had the retrofits performed, they are not included in this analysis. The ex ante savings attributed to the other four buildings have been removed from the ex ante numbers reported here.

Savings for EEM2 were modified due to two reasons. First, program calculations indicated that two cooling towers were retrofitted with VFD controls. However, the evaluation team found during the site visit that only a single unit was retrofitted as part of this project while the second motor was taken out of service entirely. Second, the evaluation team discussed with site contacts the typical performance of the chiller plant in the courthouse and jail that the cooling tower serves. Discussions revealed that the system typically operates when outdoor temperatures rise above 60°F. As such, the annual hours of operation for the cooling tower were reduced to reflect this.

In addition to the first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For the lighting fixture retrofit and VFD installation, the two baselines are identical.

For lighting retrofits (EEM1) and variable speed fans (EEM2), DEER provides an EUL of 15 years.

Table 220: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction (kW-years)	Natural Gas Energy Savings(Therms)
Baseline 1&2	5,867,715	1,415	0.0

Source: DNV KEMA analysis

Project Description

This project involved the installation of one VSD and new motor on a cooling tower fan, the removal of one cooling tower fan motor and the relamping or replacement of 3,264 fixtures throughout five Yuba County buildings. The following areas were included in the retrofit: Animal Control, Government Center, North Annex, Dan Avenue, and County Courthouse.

Measure 1 – Retrofit Light Fixtures

EEM1 consisted of a complete lighting retrofit for all five buildings involved in the project. A room-by-room lighting survey was completed, which documented baseline as well as replacement fixture types for all 3,264 fixtures replaced as part of this project. The vast majority of the line items involve the relamping of standard ballast factor 32W T8 fixtures with 28WT8 fixtures and low ballast factor high-efficiency ballasts. Additional measures included replacing incandescent exit signs with new LED fixtures and the installation of PAR30 LED fixtures.

Savings were calculated line-by-line using the following algorithm:

Annual savings (kWh) = [BFW by line using the following algorithm:rs

Where,

BFW	= Baseline fixture wattage (kW)
BFQ	= Baseline fixture quantity (#)
RFW	= Retrofit fixture wattage (kW)
RFQ	= Retrofit fixture quantity (#)
BaseRunHrs	= Preretrofit annual hours of operation for usage group
PostRunHrs	= Postretrofit annual hours of operation for usage group

HVAC interactive effects were not accounted for in the ex ante savings estimates, and similarly are also not included in the ex post analysis.

Measure 2–Install VSD on Cooling Tower Fan

According to calculations contained in the program documentation, EEM2 consisted of installing two new VSDs and motors on two cooling towers that serve the courthouse and county jail. Savings were calculated using a simple affinity law calculation, where the total run hours of each unit were estimates and the cooling load profile was assumed to be the same as the IPLV load estimates used to calculate the part-load efficiency of chillers.

Project Evaluation

An ERS engineer visited the facility on April 25, 2012, to verify the installation of each measure, verify the hours of operation with site staff, and verify that equipment specifications met those listed in the program documentation.

Measure 1 –Retrofit Light Fixtures

On-site verification activities confirmed that the lighting retrofits occurred at five of the buildings listed in the program documentation. Discussions with the Energy Commission staff confirmed an additional four buildings were retrofitted after the site visit. Because of this, the savings from those buildings are not included in this report and were marked as “not evaluated” in the tracking database. An updated lighting survey and set of savings calculations was obtained from the site contact during the visit. This new survey listed room-by-room

baseline and postinstallation fixture quantities and fixture types. ERS verified the installation of fixtures in each of the buildings that had been retrofitted at the time of the site visit.

For each major fixture type, the evaluation team verified that the lamps and ballasts installed matched those listed in the lighting survey. The evaluation team did not find any major discrepancies in the survey provided by the site contact. The findings are listed below in Figure 91.

Figure 91: Lighting Survey Adjustments

Building	Ex Ante			Ex Post		
	# of Fixtures	Electric Energy Savings (kWh)	Demand Savings (kW)	# of Fixtures	Electric Energy Savings (kWh)	Demand Savings (kW)
Courthouse & Jail	1731	131,335	39.3	1691	208,889	34.4
Government Center	654	63,295	19.0	1119	69,965	22.0
Dan Avenue	207	26,552	7.0	104	8,473	2.8
North Annex	168	27,723	8.4	174	13,362	4.8
Animal Control	154	13,000	3.8	176	26,054	5.0
Total	**2914**	**261,905**	**77.5**	**3264**	**326,742**	**69.0**

Source: DNV KEMA analysis

Figure 92 and Figure 93 below show the light fixtures and ballasts surveyed as part of the inspection process.

Figure 92: PAR30 LED Lamp

Photo Credit: DNV KEMA a

Figure 93: Parking Lot Induction Fixtures

Photo Credit: DNV KEMA

Measure 2 –Install Variable Speed Cooling Tower Fans

On-site verification activities confirmed that only one of the two cooling towers listed in the program documentation was retrofitted with a VSD while the second cooling tower was taken out of service. The evaluation team verified that the new high-efficiency inverter duty motor and variable-speed controls were installed as described in the program documentation. The evaluation team was not able to deploy data logging equipment on the cooling tower, as the chiller plant was undergoing a separate retrofit and the entire system was not operational during the visit.

The evaluation team recalculated the annual savings for this measure. The baseline system was confirmed to be a two-speed fan using both a 7.5 HP motor and a 30 HP motor, each with a NEMA nominal efficiency of 85.5 percent. Discussion with site staff revealed that the chiller plant only operates when the outdoor air temperature rises above 60°F. The evaluation team used typical California weather file for the area (climate zone 11) to estimate the annual hours of operation.

Since the performance of the system could not be monitored, the evaluation team used the same IPLV standard from the ex ante calculations to estimate the load profile. A summary of the savings calculations for the VFD is shown below in Figure 94. Annual demand savings were considered to be only the difference in motor efficiency between the baseline and installed units.

Figure 94: Annual Savings Calculations for VFD

Cooling Tower Fan

Description	HP	Estimated Load	Baseline Motor Efficiency	Installed Motor Efficiency	Total Baeline Demand kW
Cooling tower fan	30	90%	85.5%	94.0%	23.6
Total					**23.6**

Baseline fan demand	23.6	kW
Installed fan demand	21.4	kW

VFD Parameters		
Power-to-speed reduction exponent	2.5	*Range = 2.0 - 3.0*
Average VFD efficiency penalty	2.0%	

Hours of Operation		
Baseline	4,626	CZ11 -- all hours Dry Bulb > 60F
Installed	4,626	

Output Load Level	IPLV %Time at Load	Baseline w/o VFD kW	Installed w/VFD kW	Baseline 2 - Speed kWh	Installed w/VFD kWh	Energy Savings kWh
100%	1%	23.56	21.86	1,090	1,011	78
75%	42%	17.55	10.65	34,099	20,695	13,405
50%	45%	5.13	3.87	10,673	8,046	2,627
25%	12%	2.56	0.68	1,423	379	1,044
	100%		**TOTALS**	**47,285**	**30,132**	**17,154**

Source: DNV KEMA analysis

Additionally, savings were calculated for the second cooling tower that is no longer in service, as shown in Figure 95.

Figure 95: Annual Savings for Cooling Tower Taken Out of Service

Output Load Level	IPLV %Time at Load	Baseline w/o VFD kW	Baseline 2 - Speed kWh	Post retrofit kWh	Energy Savings kWh
100%	1%	23.56	1,090	0	1,090
75%	42%	17.55	34,099	0	34,099
50%	45%	5.13	10,673	0	10,673
25%	12%	2.56	1,423	0	1,423
	100%		**47,285**	**0**	**47,285**

Source: DNV KEMA analysis

Savings Results

Taking into account both EEMs, the Yuba County project resulted in 391,182 kWh in annual gross energy savings and demand savings of 94.3 kW. A breakdown of savings by individual measure is presented in Table 219 at the beginning of this report. The ex ante savings estimates,

which were acquired from the program's monthly status reports, are also provided as a point of reference.

Discussion

Measure 1 – Retrofit Light Fixtures

On-site verification activities found that the lighting measure was significantly different from the figures detailed in the program documentation as the retrofit was not complete at the time of the site visit. The evaluation team verified the installation of fixtures in each of the five buildings where the lighting retrofit had been completed. Only five of the nine buildings listed in the program documents were completed, and 3,264 of the fixtures listed in the ex ante savings calculations were confirmed.

Measure 2 –Install Variable Speed Cooling Tower Fans

As discussed previously, the evaluation team verified all equipment and analysis assumptions submitted in the original application. The evaluation team found only one of the two units listed in the ex ante calculations was installed while the other cooling tower was decommissioned. In addition, annual hours of operation for the unit was modified after discussions with site staff.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline. The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the EEM implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 221 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 221: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	391,181	94.3	0.0
2	2012	391,181	94.3	0.0
3	2013	391,181	94.3	0.0
4	2014	391,181	94.3	0.0
5	2015	391,181	94.3	0.0
6	2016	391,181	94.3	0.0
7	2017	391,181	94.3	0.0
8	2018	391,181	94.3	0.0
9	2019	391,181	94.3	0.0
10	2020	391,181	94.3	0.0
11	2021	391,181	94.3	0.0

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
12	2022	391,181	94.3	0.0
13	2023	391,181	94.3	0.0
14	2024	391,181	94.3	0.0
15	2025	391,181	94.3	0.0
	Total	5,867,715 kWh	1,415 kW	0.0 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Mariposa, County of (CBG-09-192)

Site Summary

The County of Mariposa applied for EECBG funds for four EEMs (EEMs): replacement of six aging rooftop packaged HVAC systems and thermostat controls serving the Hall of Records, Juvenile Detention Center (JDC), and the Sheriff's Dispatch facility; replacement of eight AC condenser units and thermostat controls serving the Library and Lind House; retrofits of interior to lighting fixtures/ lamps and installation of motion sensor controls at the Hall of Records, Library, Lind House, Milburn House, Juvenile Detention Center, and Sheriff's Dispatch facility; and installation of an occupancy sensing vending machine controller at the Hall of Records.

DNV KEMA performed site visits at all seven facilities that received EECBG funded energy efficiency retrofits. During the site visits, DNV KEMA verified the quantity, manufacturers, and model numbers of the all the installed HVAC equipment and a sample of the lighting equipment. DNV KEMA also gathered HVAC operational schedules and set point temperatures for all the retrofitted systems.

Spreadsheet analysis was used to estimate energy savings for all measures using a combination of site findings and literature reviews. The analysis yielded an overall annual electric energy savings of 100 percent when compared to ex ante estimates. The energy and power savings by measure are provided in Table 222.

Table 222: Energy Savings Summary by Measure Category

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Maximum Demand Reduction (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Maximum Demand Reduction (kW)	Gas Energy (Therms)	Electric	Gas
Package HVAC and Controls	4,084	9.45	505	4,084	9.45	505	100.0%	100.0%
AC Condensers and Controls	5,628	10.68	101	5,628	10.68	101	100.0%	100.0%
Interior Lighting & Controls	14,273	3.91	-	14,274	3.91	-	100.0%	-
Vending Machine Controls	1,813	0.43	-	1,813	0.43	-	100.0%	-
Total	24,268	23.1	606	24,268	23.1	606	100%	100%

Source: DNV KEMA analysis

Life-cycle savings were calculated relative to two baselines:

- Baseline 1 uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, uses *minimally code-compliant* conditions or *standard practice* as the baseline once the RUL of the pre-existing equipment is exceeded.

The overall results from Table 222 yield a life-cycle energy savings of 368,840 kWh, life-cycle demand savings of 363 kW-years, and life-cycle propane gas energy savings of 9,090 therms when considering Baseline 1 conditions. Using a dual baseline defined as Baseline 2, the life-cycle savings total 258.402 kWh, 132.9 kW-years, and 2,916 therms as shown in Table 223.

Table 223: Ex Post Life-cycle Savings Totals

Baseline Type	Electrical Energy Savings (kWh)	Electrical Demand Savings (kW-years)	Propane Gas Energy Savings (Therms)
Baseline 1	368,840	363	9,090
Baseline 2	235,402	132.9	2,916

Source: DNV KEMA analysis

Project Description

Measure 1: Package HVAC and Controls

This measure involved the replacement of six package HVAC RTUs and installation of 7-day programmable thermostats at the County Hall of Records, Juvenile Detention Center, and Sheriff's Dispatch facility. These existing and replacement equipment is listed below:

- Location: Hall of Records
  - Four 4-ton packaged RTUs
    - Existing units
      - Manufacturer: Trane
      - Model Number: YCC048F3H0B
      - 4-ton cooling capacity, 10.42 SEER
      - 80 kBTU/hr heating capacity, 72 percent AFUE
    - Replacement units
      - Manufacturer: Trane
      - Model Number: 4YCY4048A3096AB
      - 4-ton cooling capacity, 14.25 SEER
      - 77.5 kBTU/hr heating capacity, 80 percent AFUE
- Location: Juvenile Detention Center
  - One 5-ton packaged RTU
    - Existing units
      - Manufacturer: Ruud
      - Model Number: Unknown

        - 5-ton cooling capacity, 10.42 SEER
        - 77 kBTU/hr heating capacity, 72 percent AFUE
    - Replacement units
        - Manufacturer: Rheem
        - Model Number: RRPL-B060JK10X
        - 5-ton cooling capacity, 12.70 SEER
        - 77 kBTU/hr heating capacity, 80 percent AFUE
- Location: Sheriff's Dispatch facility
    - One 3.5-ton packaged RTU
        - Existing unit
        - Manufacturer: Payne
        - Model Number: 585HJ042060
        - 3.5-ton cooling capacity, 10.42 SEER
        - 60 kBTU/hr heating capacity, 72 percent AFUE
        - Replacement unit
        - Manufacturer: Goodman
        - Model Number: GPG154211541AB
        - 3.3-ton cooling capacity, 14.44 SEER
        - 91 kBTU/hr heating capacity, 80 percent AFUE

Measure 2: AC Condensers and Controls

This measure involved the replacement of eight condensing units and installation of 7-day programmable thermostats at the County Library and Lind House. These existing and replacement equipment is listed below:

- Location: County Library[41]
    - Four 5-ton AC condensing units
        - Existing units
        - Manufacturer: Rheem
        - Model Number: RAKA-060CAS
        - 5-ton cooling capacity, 10.42 SEER
        - Replacement units
        - Manufacturer: Rheem
        - Model Number: RANL-060CAZ
        - 5-ton cooling capacity, 12.70 SEER
    - Two 3.5-ton AC condensing unit
        - Existing unit

41 No information on the existing furnace/ heating equipment at the Library was provided. Therefore, KEMA was not able to calculate therm saving that may have resulted from the retrofit of the HVAC controls under this measure.

        - Manufacturer: Rheem
        - Model Number: RAKA-042CAZ
        - 3.5-ton cooling capacity, 10.42 SEER
    - Replacement unit
        - Manufacturer: Rheem
        - Model Number: RANL-043CAZ
        - 3.5-ton cooling capacity, 12.70 SEER
  - One 3-ton AC condensing unit
    - Existing unit
        - Manufacturer: Ruud
        - Model Number: UAKA-036CAS
        - 3-ton cooling capacity, 10.42 SEER
    - Replacement unit
        - Manufacturer: Rheem
        - Model Number: RANL-037CAZ
        - 3-ton cooling capacity, 12.70 SEER
- Location: Lind House
  - One 4-ton AC condensing unit
    - Existing unit
        - Manufacturer: Ruud
        - Model Number: URGG-10E43JKR
        - 3.3-ton cooling capacity, 10.0 SEER
    - Replacement unit
        - Manufacturer: Rheem
        - Model Number: RRPL-B048JK10X
        - 4-ton cooling capacity, 16.42 SEER

Measure 3: Interior Lighting and Controls

This measure involved retrofits of existing interior T8 lighting components to higher efficiency T8 fixtures and bulbs, as well as installation of occupancy sensor lighting controls. The planned lighting and control retrofits, organized by facility, are listed below:

- Library
  - x175 2-lamp retrofits from T8 to T8 (new gen) lighting
  - x12 3-lamp retrofits from T8 to T8 (new gen) lighting
  - x7 motion sensor lighting controls
- Hall of Records
  - x6 motion sensor lighting controls
- Lind House
  - x30 2-lamp retrofits from T8 to T8 (new gen) lighting
- Milburn House/ JDC
  - x 29 2-lamp retrofits from T8 to T8 (new gen) lighting
  - x5 4-lamp retrofits from T8 to T8 (new gen) lighting

- x7 motion sensor lighting controls
- Sheriff's Dispatch facility
  - x153 lamp retrofits from T8 to T8 (new gen) lighting

Measure 4: Vending Machine Controls

This measure involved the installation of an occupancy sensor control to the beverage vending machine at the Hall of Records that reduced the operating hours and thus saved energy. The occupancy sensor kept the vending machine powered off when the nearby area was vacant in order to reduce both cooling and lighting costs. The vending machine control unit installation and operation was verified during the site visit.

Ex Ante Savings

For some projects, the Energy Commission approves grants for project consisting of approved measure types but does not require submission of ex ante savings estimates for these measures. Mariposa did not submit ex ante savings estimates to the Commission for this project. DNV KEMA was asked to produce ex ante savings values for the Mariposa project as implemented rather than as planned. DNV KEMA applied the results of the on-site verification and ex post savings analysis to the ex ante savings value fields. For this reason, all measures have 100 percent realization rates.

Project Evaluation

A DNV KEMA field engineer visited the project sites on June 27nd, 2012 to verify the measure installations and gather data on equipment model numbers, quantities, and control schemes. Table 224 summarizes the results of the installation verification.

Table 224: Verification Summary

Site	Equipment	Reported	Verified	Site Notes
Hall of Records	4-ton Package RTUs	4	4	
Sheriff's Dispatch	3.5-ton Package RTU	1	1	Capacity of new unit is 3.3-tons, existing unit was 3.5-ton
JDC	5-ton Package RTU	1	1	
Lind House	4-ton AC Condenser	1	1	
Library	5-ton AC Condenser	4	4	
Library	3.5-ton AC Condenser	2	2	
Library	3-ton AC Condenser	1	1	
Hall of Records, JDC, Library, Lind House, Sheriff's Dispatch	7 Day Programmable Thermostats	14	14	

Site	Equipment	Reported	Verified	Site Notes
JDC, Library, Lind House, Milburn House, Sheriff's Dispatch	New T8 Fluorescent Bulbs	677	524	No bulb retrofits at JDC (54). Bulb replacements at Sheriff's Dispatch facility not verified due to limited time and access (153 bulbs)
Hall or Records, JDC, Library, Lind House	Lighting Control Occupancy Sensors	26	20	No occupancy sensors installed at Lind House (6),
Hall of Records	Vending Machine Controls	1	1	

Source: DNV KEMA analysis

Measure 1: Package HVAC and Controls

The ex post Measure 1 savings analysis was based upon a five-degree (˚F), weather bin analysis spreadsheet method utilizing the local TMY3 weather data set, operating schedules and set point temperatures to derive heating and cooling loads. The bin analysis assumed the following: the HVAC equipment is properly sized to meet heating and cooling loads of buildings and the heating and cooling loads are ambient-temperature driven and have a near-linear relationship with ambient temperature.

During the site visit, DNV KEMA verified the installations of the HVAC equipment, acquired model numbers and capacity nameplate information, and gathered operational schedules and set point temperatures from the site contact. Subsequently, DNV KEMA determined heating and cooling efficiency values for the RTUs from manufacturer literature and gathered TMY3 hourly, ambient dry-bulb temperature data from the nearby Merced-Macready airport.

Per the set point temperature information provided by the site contact, the building cooling load occurs between the 70-75°F ambient temperature bin and the 105-110°F bin while the building heating load occurs between 70-75°F ambient temperature bin and the below 30°F bin. The bin analysis model considers the pre and post measure hours of operation along with flags set to indicate cooling and heating months.

Mariposa lies within California Climate Zone 12, which The Pacific Energy Center's *Guide to California Climate Zones and Bioclimatic Design, October 2006* describes as experiencing "cooler winters and hotter summers than climate Zone 3 (Bay Area)," and for which "High temperatures are usually more than 100 F. While the marine air may influence temperatures in that area closest to the Bay Area, the ocean influence is negligible on the hottest days when winds blow off shore."

The cooling months used in the analysis were May through September, when the average ambient temperature for California climate zone 12 is above 60°F and the maximum ambient temperatures reach into the mid 90°F range. A review of billing data for the Hall of Records and Library facilities shows an increase in monthly kWh consumption for the May through September period, further supporting this cooling period designation. Alternatively, heating was modeled for the months from October through April, when the average ambient temperature for California climate zone 12 is below 60°F and the minimum ambient temperatures dip into the high 30°F range.

The hours and days of operation for the HVAC systems under pre and postretrofit conditions are shown below in Table 225.

Table 225: Measure 1 HVAC Schedules

	Existing Weekday Schedule			Existing Weekend Schedule			Postretrofit Weekday Schedule			Postretrofit Weekend Schedule		
Location	Weekdays	On	Off	Weekends	On	Off	Weekdays	On	Off	Weekends	On	Off
Detention Center	Mon-Fri	6:00 a.m.	10:00 p.m.	Sat-Sun	6:00 a.m.	10:00 p.m.	Mon-Fri	6:00 a.m.	10:00 p.m.	Sat-Sun	6:00 a.m.	10:00 p.m.
HR: Assessor	Mon-Fri	6:00 a.m.	8:00 p.m.	Sat-Sun	6:00 a.m.	8:00 p.m.	Mon-Fri	6:00 a.m.	8:00 p.m.	Sat-Sun	6:00 a.m.	8:00 p.m.
HR: Appraiser	Mon-Fri	6:00 a.m.	8:00 p.m.	Sat-Sun	6:00 a.m.	8:00 p.m.	Mon-Fri	6:00 a.m.	8:00 p.m.	Sat-Sun	6:00 a.m.	10:00 p.m.
HR: Clerks	Mon-Fri	7:00 a.m.	6:00 p.m.	Sat-Sun	6:00 a.m.	6:00 p.m.	Mon-Fri	7:00 a.m.	6:00 p.m.	Sat-Sun	7:00 a.m.	10:00 p.m.
HR: Auditors	Mon-Fri	6:00 a.m.	10:00 p.m.	Sat	6:00 a.m.	10:00 p.m.	Mon-Fri	6:00 a.m.	10:00 p.m.	Sat	6:00 a.m.	10:00 p.m.
Sheriff's Dispatch	Mon-Fri	6:00 a.m.	10:00 p.m.	Sat-Sun	6:00 a.m.	10:00 p.m.	Mon-Fri	6:00 a.m.	10:00 p.m.	Sat-Sun	6:00 a.m.	10:00 p.m.

Source: DNV KEMA analysis

In regards to cooling for Baseline 1, all SEER values for existing units were reduced by 13 percent (10 percent reduction of EER) from the value listed in the project description to account for age-related performance degradation. For Baseline 2, all replacement units were calculated against a SEER value of 12.70 (EER of 11.0).

In regards to heating for Baseline 1, all AFUE values for existing units were reduced by 10 percent from the value listed in the project description to account for age-related performance degradation. For Baseline 2, all replacement units were calculated against an AFUE value of 78.

Electric demand savings for the cooling equipment were calculated at full-load cooling capacity by taking the difference between the energy consumption of the high-efficiency replacement units and that of the existing units (for Baseline 1 conditions) or that of normal-efficiency replacement units (for the Baseline 2 conditions).

The ex post analysis results for Baseline 1 conditions can be seen below in Table 226.

Table 226: Measure 1 Ex Post Savings Calculation Summary

Location	Cooling Capacity (Tons)	Heating Capacity (kBTU/hr)	# of Units	Existing kWh	Existing Therms	Postretrofit kWh	Postretrofit Therms	kWh Savings	Therm Savings	kW Savings
Detention Center	5	77	1	3,235	1,262	2,514	1,136	721	126	1.55
HR: Assessor	4	96	1	2,527	1,101	1,816	961	711	140	1.58
HR: Appraiser	4	96	1	2,527	1,101	1,829	1,010	698	91	1.58
HR: Clerks	4	96	1	2,287	784	1,702	807	585	-23	1.58
HR: Auditors	4	96	1	2,257	1,139	1,622	994	635	145	1.58
Sheriff's Dispatch	3.5	91.2	1	2,283	422	1,549	396	734	26	1.58
Total	24.5	552.2	6	15,116	5,809	11,032	5,034	4,084	505	9.45

Source: DNV KEMA analysis

This analysis yielded a first-year annual energy savings of 4,084 kWh, electric demand savings of 9.45 kW, and gas energy savings of 505 therms when considering Baseline 1 conditions.

Measure 2: AC Condensers and Controls

The ex post Measure 2 savings analysis was based upon the same five-degree (˚F), weather bin analysis spreadsheet method utilized for the Measure 1 analysis.

The hours and days of operation for the HVAC systems under pre and postretrofit conditions are shown below in Table 227.

Table 227: Measure 2 HVAC Operating Schedules

	Existing Weekday Schedule			Existing Weekend Schedule			Postretrofit Weekday Schedule			Postretrofit Weekend Schedule		
Location	Week-days	On	Off	Week-ends	On	Off	Week-days	On	Off	Week-ends	On	Off
Library	Mon-Fri	6:00 a.m.	10:00 p.m.	Sat-Sun	6:00 a.m.	10:00 p.m.	Mon-Fri	6:00 a.m.	10:00 p.m.	Sat-Sun	6:00 a.m.	10:00 p.m.
Lind House	Mon-Fri	6:00 a.m.	10:00 p.m.	Sat-Sun	6:00 a.m.	10:00 p.m.	Mon-Fri	6:00 a.m.	10:00 p.m.	Sat-Sun	6:00 a.m.	10:00 p.m.

Source: DNV KEMA analysis

In regards to cooling for Baseline 1, all SEER values for existing units were reduced by 13 percent (10 percent reduction of EER) from the value listed in the project description to account

for age-related performance degradation. For Baseline 2, all replacement units were calculated against an SEER value of 12.70 (EER of 11.0).

In regards to heating for Baseline 1, all AFUE values for existing units were reduced by 10 percent from the value listed in the project description to account for age-related performance degradation. For Baseline 2, all replacement units were calculated against an AFUE value of 78.

The ex post analysis results for Baseline 1 conditions can be seen below in Table 228.

Table 228: Measure 2 Ex Post Savings Calculation Summary

Location	Cooling Capacity (Tons)	Heating Capacity (kBTU /hr)	# of Units	Existing kWh	Existing Therms	Post Retro-fit kWh	Post Retro-fit Therms	kWh Sav-ings	Therm Sav-ings	kW Savings
Library	5	-	4	13,115	0	10,140	0	2,975	0	6.40
Library	3.5	-	2	4,590	0	3,549	0	1,041	0	2.24
Library	3	-	1	1,967	0	1,521	0	446	0	0.96
Lind House	4	77	1	3,148	759	1,981	657	1,166	101	1.08
Total		77	8	22,820	759	17,191	657	5,628	101	10.68

Source: DNV KEMA analysis

This analysis yielded a first-year annual energy savings of 5,628 kWh, electrical demand savings of 10.68 kW, and gas energy savings of 101 therms when considering Baseline 1 conditions.

Measure 3: Interior Lighting and Controls

The ex post savings calculations for lighting and control retrofits were performed using spreadsheet based engineering calculations.
The electrical energy savings analysis method for retrofitted fixtures calculated the existing and postretrofit annual kWh energy consumption of each unique combination of fixture location and type. The difference in annual energy consumption from the existing case to the postretrofit case is the annual energy savings for the lighting. The input parameters to calculate annual energy consumption are: fixture input power, fixture quantity, and annual operating hours. The annual kWh electrical energy consumption equation for each lighting group is shown below:

$$Annual\ kWh_{lighting\ group} = \frac{input\ power\ (W) \cdot \#\ of\ Fixtures \cdot Annual\ operating\ hours}{1000\,\frac{W}{kW}}$$

Annual kWh energy savings is then calculated using the equation below:

$$Annual\ kWh\ savings_{lighting\ group} = \left[Annual\ kWh_{existing} - \ Annual\ kWh_{retrofit}\right]$$

The electrical energy savings analysis method for occupancy sensor controls was calculated using the same equations as the retrofitted fixtures, but a thirty percent reduction in operating hours for the postretrofit condition was assumed for all fixtures operating on the retrofitted control.

Total kWh electrical energy savings was then calculated from the sum of the kWh savings from all lighting and control groups.

The ex post kW demand savings for lighting retrofits was calculated as the difference in total power for each grouping of fixture types and location. The equation for the difference in total power for each lighting group is show below:

$$kW\ savings_{lighting\ group} = \frac{\left[input\ power\ (W)_{existing} - input\ power\ (W)_{retrofit}\right]}{1000\frac{W}{kW}} \cdot \#\ of\ Fixtures$$

The ex post kW demand savings for control retrofits was calculated as the total wattage connected to the control, multiplied by the following factors:

- Annual lighting control energy savings factor (30 percent)
- Summer Peak Coincidence factor (60 percent)

The equation for the kW demand savings for occupancy sensor lighting control retrofits is shown below:

$$kW\ savings_{control\ group} = \frac{input\ power\ (W)_{retrofit}\ \times\ \#\ of\ Fixtures}{1000\frac{W}{kW}} \times .30 \times .60$$

The total demand savings were calculated from the sum of the kW savings from all lighting and control groups.

On the next page, Table 229 shows the input parameters and savings results for all fixture and control types.

Table 229: Measure 3 Ex Post Savings Calculations

Site ID / Location	Existing Fixture Description	Existing Fixture Watt	Fixture Count	Annual Oper. hours	Annual kWh Consump.	Retrofit Fixture Description	Retro-fit Fixture Watt	Retro-fit Fixture Count	Annual Oper. Hours	Annual kWh Con-sump.	Annual kWh Savings	Demand Savings, kW
Library	2-Lamp T8	64	169	5,664	61,262	2-Lamp T8 (new gen)	56	169	5,664	53,604	7,658	1.35
Library	3-Lamp T8	96	10	5,664	5,437	3-Lamp T8 (new gen)	84	10	5,664	4,758	680	0.12
Library	2-Lamp T8	64	6	5,664	2,175	2-Lamp T8 (new gen) on motion sensors (x6)	56	6	3,965	1,332	843	0.11
Library	3-Lamp T8	96	2	5,664	1,087	3-Lamp T8 (new gen) on motion sensor (x1)	56	2	3,965	444	643	0.10
Lind House	2-Lamp T8	64	30	2,490	4,781	2-Lamp T8 (new gen)	56	30	2,490	4,183	598	0.24
Milburn House	2-Lamp T8	64	27	2,750	4,752	2-Lamp T8 (new gen)	56	27	2,750	4,158	594	0.22
Milburn House, JDC	2-Lamp T8	64	2	2,750	352	2-Lamp T8 (new gen) on motion sensors (x2)	64	2	1,925	246	106	0.02
Milburn House	23W CFL	23	2	2,750	127	23W CFL on motion sensors (x2)	23	2	1,925	89	38	0.01
Milburn House, JDC	4-Lamp T8	128	5	2,750	1,760	4-Lamp T8 on motion sensors (x3)	128	5	1,925	1,232	528	0.12
Hall of Records	2-Lamp T8	64	3	2,500	480	2-Lamp T8 on motion sensors (x3)	64	3	1,500	288	192	0.03
Hall of Records	2-Lamp T8	64	18	2,500	2,880	2-Lamp T8 on motion sensors (x3)	64	18	1,750	2,016	864	0.21

Site ID / Location	Existing Fixture Description	Existing Fixture Watt	Fixture Count	Annual Oper. hours	Annual kWh Consump.	Retrofit Fixture Description	Retro-fit Fixture Watt	Retro-fit Fixture Count	Annual Oper. Hours	Annual kWh Con-sump.	Annual kWh Savings	Demand Savings, kW
Sheriff's Dispatch	32W T8 Lamps	32	153	2,500	12,240	28W T8 (new gen) Lamps	28	153	2,500	10,710	1,530	1.38
	Totals		427		97,333	Totals		427		83,060	14,273	3.91

Source: DNV KEMA analysis

For three occupancy sensors at the Hall of Records, the light fixtures and controls are located in bathrooms. The postretrofit operating hours have been reduced by 40 percent—ten percent more than the other occupancy sensor controls—to account for the expected lower occupancy rate for these space types.

This analysis yielded a first-year annual energy savings of 14,273 kWh and a first-year electrical demand savings of 3.91 kW under Baseline 1 conditions.

Measure 4: Vending Machine Controls

The ex post savings calculations for the vending machine control utilized a spreadsheet based savings analysis tool provided by the control manufacturer, Vending Miser. Input variables for the model include weekly hours of occupancy, number of cold drink vending machines, power requirements of the vending machine, hours of air-conditioning per week, and weeks of AC usage per year. The analysis tool considers the primary energy saved due to the reduced refrigeration and lighting requirements of the vending machine, as well as the energy savings resulting from reduced air condition required to offset the refrigeration heat rejection. The values used for the model input variables were as follows:

- Building occupancy: 70 hours per week
- Number of cold drink vending machines: 1
- Power requirements: 427 average watts (default value)
- Hours of AC per week: 70 hours
- Weeks of AC per year: 18 weeks per year

Using these values, the analysis model calculated the annual kWh consumption for the existing and postretrofit conditions. Annual kWh energy savings is the difference between existing and postretrofit conditions. The kW demand savings for this measure was calculated as the difference in power consumption between the on and off modes of the vending machine, which in this case was the model default is 427 watts, or 0.427 kW. The results of this analysis are presented below in Table 230.

Table 230: Measure 3 Ex Post Savings Summary

Existing kWh	Postretrofit kWh	kWh Savings per Year	kW Savings
3,999	2,186	1,813	0.43

Source: DNV KEMA analysis

Savings Results and Discussion

The project saved 24,690 kWh of electric energy and 631 therms of gas energy in the first year. Furthermore, the project reduced summer on-peak demand by 23.1 kW in the first year.

Measure 1: Package HVAC and Controls

Sources of uncertainty regarding these HVAC calculations included the assumed level of degradation of the existing equipment, reliance on-site contact reported preretrofit operating conditions, reliance on billing data to calibrate pre-retrofit modeled energy use, and the assumptions inherent in the bin analysis method regarding equipment sizing and building cooling and heating loads being primarily weather dependent.

Measure 2: AC Condensers and Controls

Sources of uncertainty regarding these HVAC calculations included the assumed level of degradation of the existing equipment, reliance on-site contact reported preretrofit operating conditions, reliance on billing data to calibrate pre-retrofit modeled energy use, and the assumptions inherent in the bin analysis method regarding equipment sizing and building cooling and heating loads being primarily weather dependent.

Measure 3: Interior Lighting and Controls

Sources of uncertainty regarding these calculations stemmed from assumptions regarding operating hours and total wattages for the fixtures.

Measure 4: Vending Machine Controls

Sources of uncertainty regarding these stemmed from assumptions regarding the average power consumption of the vending machine, the occupied hours per week, and controller settings such as duration of auto repower periods and time between auto repower periods.

Ex Post Life-cycle Savings

Energy savings for this program are calculated relative to two established baselines, referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the EUL of the new equipment. In contrast, Baseline 2 uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's RUL. After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code compliant conditions or standard practice when no code is applicable.

EUL values for the four measures were sourced from the 2011 DEER database, while the RULs were calculated from the age of the existing equipment at the time of retrofit and the measure EUL.

Table 231 displays the first year savings used to calculate the Baseline 1 and Baseline 2 life-cycle savings. Table 231 also lists the effective and remaining useful lives of each measure. Table 232 presents the electrical energy, electrical demand, and natural gas energy savings according to Baseline 1 conditions for each year the measure is in place up to the end of the measure's EUL. Table 233 presents the yearly life-cycle savings values according to Baseline 2 conditions.

Table 231: Values Used in Ex Post Life-cycle Savings Calculations

Measure	Early Replacement			Expected Replacement			EUL (years)	RUL (years)
	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Electric Demand (kW)	Gas Energy (Therms)		
Package HVAC and Controls	4,084	9.45	505	711	1.62	136	15	1
AC Condensers and Controls	5,628	10.68	101	360	0.67	17	15	3
Interior Lighting & Controls	14,273	2.53	0	14,273	3.91	0	15	11
Vending Machine Controls	1,813	0.43	0	1,813	0.43	0	5	0
Total	25,798	23.08	606	17,157	6.63	153	-	-

Source: DNV KEMA analysis

Table 232: Baseline 1 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	25,798	24.46	606
2	2013	25,798	24.46	606
3	2014	25,798	24.46	606
4	2015	25,798	24.46	606
5	2016	25,798	24.46	606
6	2017	23,985	24.04	606
7	2018	23,985	24.04	606
8	2019	23,985	24.04	606
9	2020	23,985	24.04	606
10	2021	23,985	24.04	606
11	2022	23,985	24.04	606
12	2023	23,985	24.04	606
13	2024	23,985	24.04	606
14	2025	23,985	24.04	606
15	2026	23,985	24.04	606
Life-cycle	Total	368,840 kWh	363 kW-years	9,090 Therms

Source: DNV KEMA analysis

Table 233: Baseline 2 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2012	25,798	24.5	606
2	2013	22,425	16.6	237
3	2014	22,425	16.6	237
4	2015	17,157	6.6	153
5	2016	17,157	6.6	153
6	2017	15,344	6.2	153
7	2018	15,344	6.2	153
8	2019	15,344	6.2	153
9	2020	15,344	6.2	153
10	2021	15,344	6.2	153
11	2022	15,344	6.2	153
12	2023	15,344	6.2	153
13	2024	15,344	6.2	153
14	2025	15,344	6.2	153
15	2026	15,344	6.2	153
Life-cycle Total		258,402 kWh	132.9 kW-years	2,916 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Shasta, County of (CBG-09-194-A)

Site Summary

This project involved chiller and ventilation upgrades in the County Jail as well as packaged rooftop unit (RTU) replacement and occupancy sensor and LED exit sign installation in the Coroner's Office, Cascade Office, and Public Health Building. Typical operating hours for the Coroner's Office, Cascade Office, and Public Health Building are 7 a.m. to 6p.m. Monday through Friday, with limited operation on the weekend for cleaning services. The county jail operates 24 hours per day.

The implemented measures at Shasta County buildings included a chiller upgrade at the county jail (EEM1); the installation of two VFD controlled exhaust fans at the jail to control underground parking garage (EEM2) and kitchen hood exhaust (EEM3); the installation of LED exit signs and occupancy sensors to control closed office lighting in four buildings (EEM4); and the installation of twenty-two new packaged high-efficiency RTUs in three county buildings (EEM5). According to the tracking data, an additional lighting measure (high efficiency T8s) was added after this evaluation was completed.

Table 234: Energy Savings Summary

Measure	Ex Ante			Ex Post – Baseline 1			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 – high efficiency chillers	231,227	54		187,707	61.35		81%	N/A
EEM2 – parking garage VFD exhaust	17,718	2.2		19,276	2.17		109%	N/A
EEM3 – kitchen hood VFD exhaust	32,452	9.4	1470	14,172	3.93	1470	44%	
EEM4 – indoor lighting upgrade	109,326	3.7		109,326	3.7		100%	
EEM5 – high efficiency rooftop HVAC units	15,351	17		8,814	6.8		57%	

Measure	Ex Ante			Ex Post – Baseline 1			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
Total	406,074	86.3	1470	339,295	78.0	1470	78%	100%

Source: DNV KEMA analysis

Overall, the ex post energy savings are 84 percent of the ex ante's estimates. The differences in energy savings are outlined briefly below for each EEM.

For EEM1, there are fundamental differences in the energy savings calculation methodology. Ex post used a complete 8,760 model to determine energy savings. This is done in conjunction with chiller logs on actual chiller performance in the postretrofit period and was calibrated using actual billing data from a meter dedicated to the chiller. In comparison, savings in the program documentation were calculated using a Trane Trace 700 model, which was erroneously based on calibration efforts to billing data for the Jail's lighting and plug loads (as opposed to the actual chiller itself). Correcting this error reduced the total chiller plant's annual full-load hours from 4,129 hours to 1,540 hours in the ex post analysis. The nominal chiller efficiency was much better than anticipated in the ex ante calculations, which increased measure savings. Finally, the ex ante savings were not calculated using a dual baseline methodology. Since the chillers that were replaced were 29 years old and site contacts indicated that they had a useful life of only two additional years, savings calculations were made comparing the new chillers to both the existing units as well as Title 24 code-compliant units.

For EEM2, the equipment was metered for three weeks to determine the part-load operating profile of the new carbon monoxide sensor-based system. The metered data showed that total annual hours of operation were dropped from 8760 to 146 hours per year. The system performed extremely well during the evaluation team's site visit. No major changes were made to the savings calculation methodology.

For EEM3, the equipment was metered for three weeks to determine the part-load operating profile of the new intelligent hood exhaust system. Spot measurements showed that the fan load factor was much lower than originally assumed in the ex ante calculations. The reduction in baseline fan loading from 90 percent to 68 percent (based on the evaluation team's spot measurements) accounted for the majority of the difference in the annual savings figures.

For EEM4, a sample of occupancy sensor and LED exit signs were surveyed. All units were installed properly and functioning correctly. No changes were made to the ex ante savings calculations.

For EEM5, the site visit revealed that only nine of the twenty-two units listed in the ex ante calculations were installed. The California Energy Commission (Energy Commission) verified that the final scope was reduced to nine units. The 13 units listed for the Public Health building were not replaced. All nine units were installed properly and functioning correctly. Ex ante savings calculations were made using a Trane Trace 700 model, assuming a SEER (Seasonal Energy Efficiency Ratio) of 14. The installed units had SEERs ranging from 13 to 13.2 which

were accounted for in the ex post analysis using a standard effective full load hour (EFLH) calculation spreadsheet.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For EEM1, Baseline 1 is the two previously installed 125-ton centrifugal chillers and Baseline 2 is a Title 24-compliant centrifugal chiller with a nominal full load coefficient of performance (COP) of 6.1.

For EEM5, Baseline 1 is the previously installed packaged RTUs and Baseline 2 is a California Appliance Standard-compliant packaged unit with a nominal SEER of 13.

For the remaining measures, Baseline 1 and Baseline 2 are the same.

For the chiller retrofit (EEM1), DEER provides an EUL of 20 years. For the VFD exhaust measures (EEM2 & EEM3) and the packaged HVAC units (EEM5), DEER provides an EUL of 15 years. Finally, for the lighting retrofits (EEM4), DEER provides an EUL of 15 years.

Table 235: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction (kW)	Natural Gas Energy Savings(Therms)
Baseline 1	6,027,960	77.95	22,050
Baseline 2	4,726,599	77.95	22,050

Source: DNV KEMA analysis

Project Description

This project involved chiller and ventilation upgrades in the County Jail as well as packaged RTU replacement and occupancy sensor and LED exit sign installation in the Coroner's Office, Cascade Office, and Public Health Building.

Measure 1 – High Efficiency Chillers

EEM1 consisted of the replacement of two 125-ton centrifugal chillers with two new 140-ton magnetic drive centrifugal chillers. The existing units were 27 years old, and site contacts described the units as leaking refrigerant and with only two more years of service life.

Measure 2 – Parking Garage VFD Exhaust

EEM2 consisted of installing a VFD on the indoor garage exhaust fan as well as carbon monoxide sensors throughout the garage. Prior to the system's installation, the garage exhaust operated on a single-speed drive 8,760 hours per year. The new carbon monoxide sensor-based system only activates the fans when cars are idling in the garage.

Measure 3 – Kitchen Hood VFD Exhaust

EEM2 consisted of installing a VFD and sensors on the kitchen hoods in the jail building. Prior to the system's installation, the fans operated on a timer and single-speed drive for 5,110 hours per year. The new system contains an exhaust gas sensor that varies the exhaust fan speed based on the exhaust particulate levels.

Measure 4 – Indoor Lighting Upgrade

EEM4 consisted of installing occupancy sensors and LED exit signs in the Coroner's Office, Cascade Office, Public Health Building, and County Jail.

Measure 5 - High Efficiency Rooftop HVAC Units

EEM5 consisted of installing new packaged HVAC units in three buildings. Site inspections confirmed that the nine units in the final project scope were installed.

Ex Ante Savings

Savings for EEM1, EEM4, and EEM5 were calculated using a Trane Trace 700 model. The complete model was not made available to the evaluation team, but descriptions of the inputs as well as detailed model outputs were included in the program documentation.

Savings for the two VFD exhaust measures (EEM2 & EEM3) were calculated using spreadsheet models provided by the vendor. The original spreadsheets were not provided for review, but outputs were included in the program documentation.

Project Evaluation

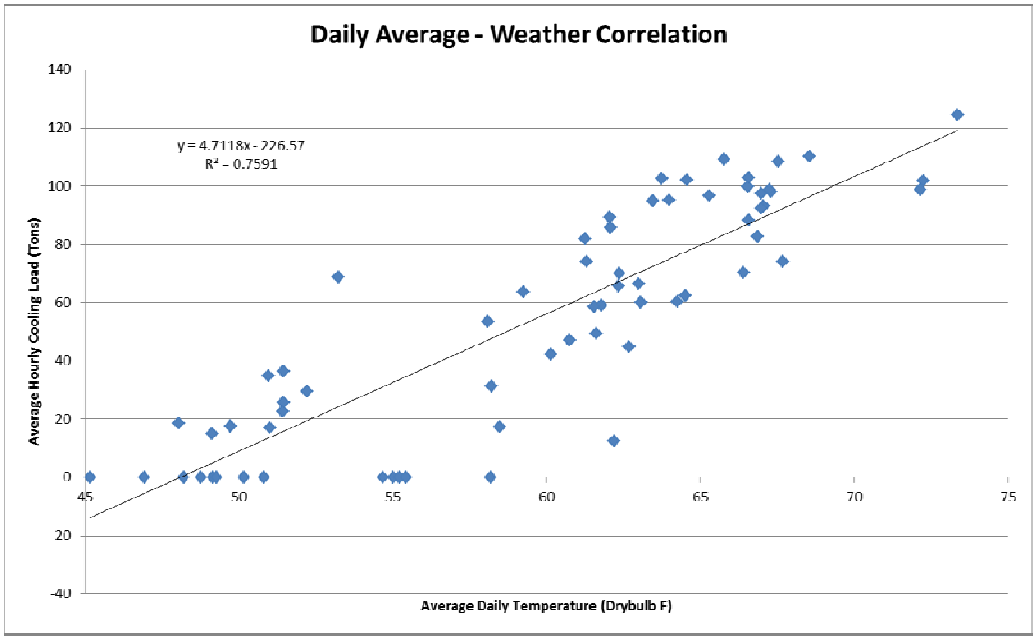
An ERS engineer visited the facility on February 16, 2012, to verify the installation of each measure, verify the hours of operation with site staff, ensure that the equipment specifications met those listed in the program documentation, and install data logging equipment. Amperage meters were installed on the two VFD exhaust fans (EEM2 &EEM3) to determine the part-load usage patterns. Due to the large number of light fixtures and occupancy sensors installed as part of EEM4, the evaluation team only inspected a sample of the fixtures installed as part of this measure. The quantity of lighting fixtures sampled is expected to be representative of the project as a whole based on lighting fixture types, locations, and operating profiles.

Measure 1 – High Efficiency Chillers

On-site verification activities confirmed that two 140-ton magnetic drive centrifugal chillers were installed in the jail, as detailed in the program documents. The new chillers utilize the existing cooling towers as well as chiller water pumps. The units were not operating during the site inspection; however, the evaluation team was able to access the internal chiller logs of the units and retrieve 15-minute performance data from the six months that the units have been operational since their installation.

The data retrieved from the chiller logs was analyzed to relate chiller electrical demand (kW) and chiller load (tons) to outdoor conditions. Fits to outdoor temperature, relative humidity, and temperature-humidity index[42] ([THI], which accounts for both sensible and latent conditions) were considered. Ultimately, the dry-bulb fit was used because it maximized the correlation relative to the other two options. Figure 96 presents the metered data cloud and the corresponding regression fit.

Figure 96: Chiller Load Correlation



Source: DNV KEMA analysis

A review of the metered data and the regression results yielded two important conclusions. First, the chiller does not operate once outdoor air temperatures drop below 45°F–50°F. Second, the chiller loads are heavily driven by outdoor conditions.

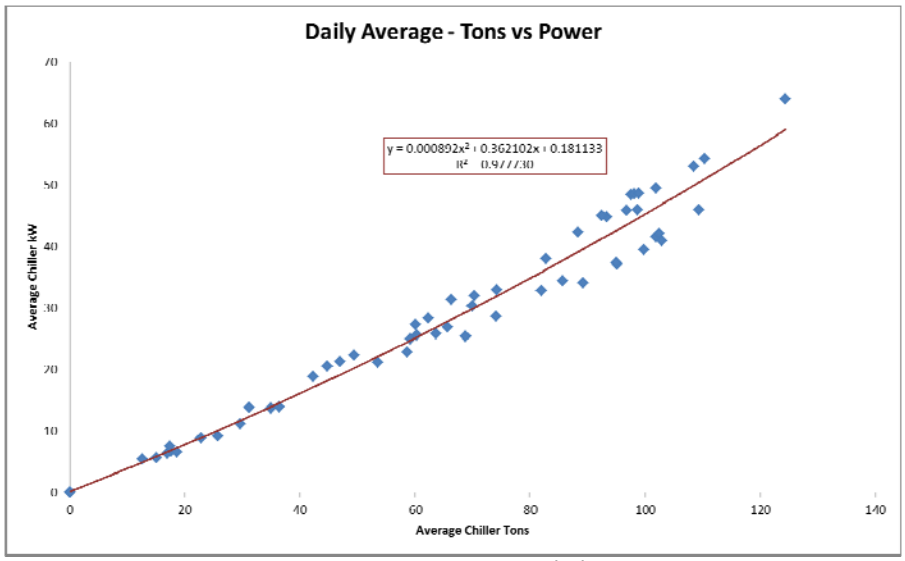
Using the regression trend in Figure 96 and weather data from the CZ11 file for Red Bluff, an annual profile of the installed case chiller's load was generated. Using the part-load efficiency curve developed for the new compressor from metered data correlation in Figure 97, the annual installed chiller electric use was determined. Finally, the base-case compressor's electrical demand was then projected using the nominal full-load efficiency with the eQuest part-load chiller efficiency correction factor of both the existing chiller (Baseline 1) and Title 24-compliant

42Defined as in accordance with the New England ISO definition.

chiller (Baseline 2). A comparison of the part-load efficiency of the three chiller types in the model is presented Figure 98. The existing chiller had a nominal efficiency of 0.8 kW/ton, and due to the age of the unit, a 10 percent degradation factor was incorporated into its performance. The Title 24-compliant chiller is based on a unit with a COP of 5.0, as specified in Table 112-D of the 2008 Building Energy Efficiency Standards.

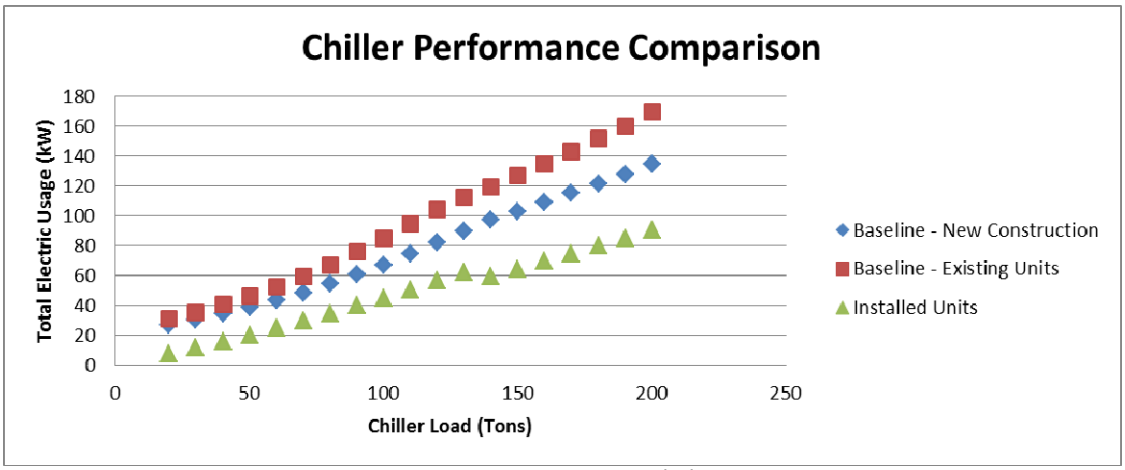
Savings during each hour were then calculated on the basis of the difference between the Turbocor and the two baseline compressors' electrical demand.

Figure 97: Metered Turbocor Chiller Performance



Source: DNV KEMA analysis

Figure 98: Modeled Chiller Plant Performance



Source: DNV KEMA analysis

Measure 2 – Retrofit Outdoor Light Fixtures

On-site verification activities confirmed that the fans, carbon monoxide sensors, and variable-speed controls were installed as described in the program documentation. The evaluation team deployed data logging equipment on the supply fan for a period of three weeks. The metered data is presented in Figure 99. The annual savings were calculated using the same methodology as the ex ante program documents and are detailed below in Figure 100.

Figure 99: Metered Fan Run Time

Weekly Fan % Run Time								
% Time On	Weekday							
Hour	1	2	3	4	5	6	7	Average
0	0.0%	0.0%	1.1%	0.0%	0.0%	0.0%	3.3%	0.7%
1	0.0%	0.0%	0.0%	0.0%	2.2%	4.4%	1.1%	1.2%
2	0.0%	0.0%	0.0%	0.0%	3.3%	0.0%	0.0%	0.5%
3	0.0%	0.0%	0.0%	1.7%	1.1%	2.2%	2.2%	1.0%
4	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%	1.1%	0.2%
5	0.0%	0.0%	1.1%	1.7%	0.0%	0.0%	1.1%	0.5%
6	0.0%	2.2%	1.1%	0.0%	0.0%	0.0%	0.0%	0.5%
7	0.0%	5.6%	0.0%	0.0%	0.0%	0.0%	0.0%	0.8%
8	4.4%	6.7%	4.7%	10.0%	4.4%	1.1%	1.1%	4.4%
9	6.7%	6.7%	0.0%	0.0%	1.1%	0.0%	0.0%	2.3%
10	5.6%	8.9%	3.3%	5.0%	1.1%	0.0%	0.0%	3.3%
11	3.3%	2.2%	1.7%	3.3%	10.0%	0.0%	0.0%	3.0%
12	2.2%	6.7%	1.7%	2.2%	2.2%	0.0%	0.0%	2.2%
13	5.6%	2.2%	8.3%	1.1%	3.3%	0.0%	0.0%	2.7%
14	3.3%	4.4%	0.0%	3.3%	2.2%	1.1%	1.1%	2.3%
15	2.2%	14.4%	3.3%	3.3%	1.1%	0.0%	0.0%	3.5%
16	5.6%	6.7%	1.7%	1.1%	0.0%	1.1%	1.1%	2.5%
17	3.3%	0.0%	3.3%	0.0%	1.1%	3.3%	1.1%	1.7%
18	1.1%	3.3%	3.3%	0.0%	3.3%	0.0%	0.0%	1.5%
19	2.2%	1.1%	1.7%	0.0%	3.3%	0.0%	3.3%	1.7%
20	1.1%	2.2%	0.0%	3.3%	2.2%	1.1%	0.0%	1.5%
21	0.0%	1.1%	1.7%	1.1%	0.0%	0.0%	1.1%	0.7%
22	1.1%	1.1%	3.3%	2.2%	1.1%	0.0%	1.1%	1.3%
23	1.1%	1.1%	0.0%	0.0%	0.0%	2.2%	0.0%	0.7%
Average	**2.0%**	**3.2%**	**1.5%**	**1.6%**	**1.8%**	**0.7%**	**0.8%**	**1.7%**

Source: DNV KEMA analysis

Figure 100: Annual Savings Calculations

Description	HP	Qty	Estimated Load	Efficiency	Demand kW	Total Demand kW
Garage exhaust fan	3	1	80%	80.0%	2.2	2.2
Total		**1**				**2.2**

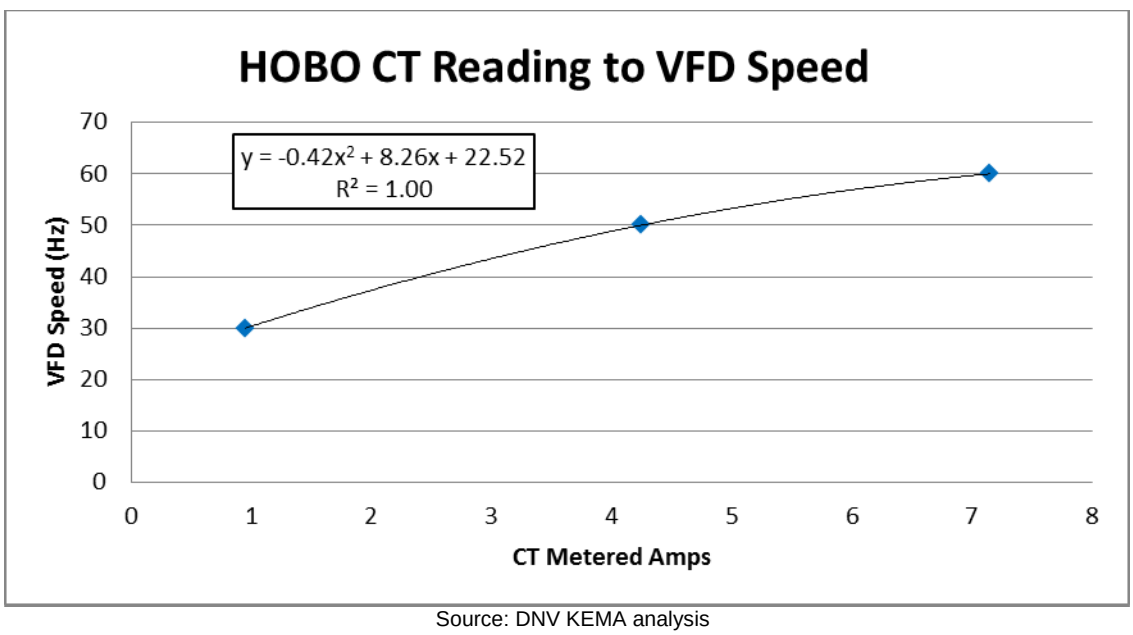
	Annual hrs of operation	% Time on	kW	Annual kWh
Baseline	8760	100%	2.2	19,605
Installed	8760	1.7%	2.2	329
			Total savings	**19,276**

Source: DNV KEMA analysis

Measure 3 – Kitchen Hood VFD Exhaust

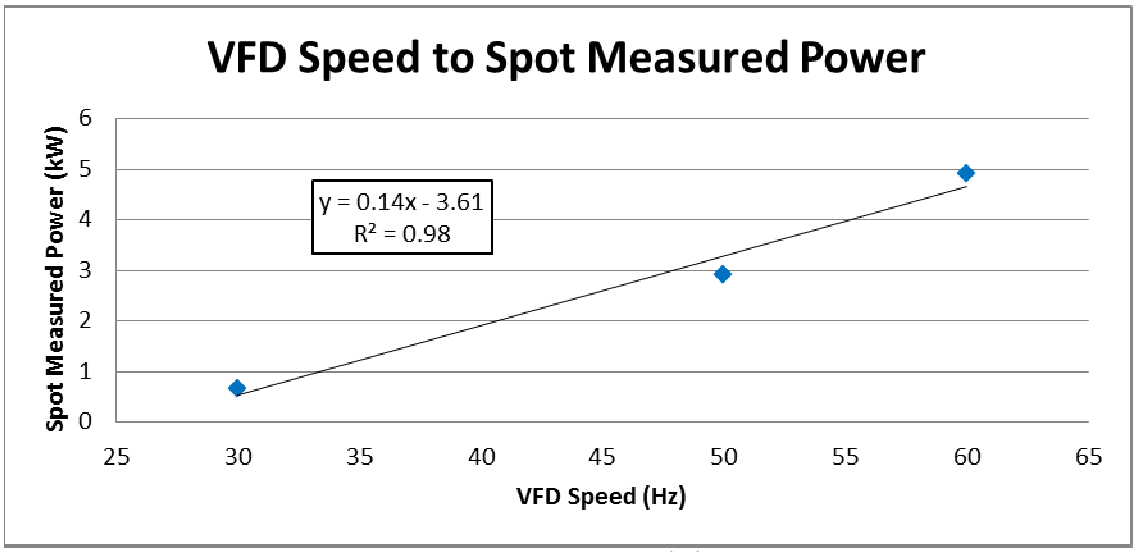
On-site verification activities confirmed that the fans, sensors, and variable-speed controls were installed as described in the program documentation. The evaluation team deployed data logging equipment on the supply fan for a period of three weeks. Both the supply and exhaust fans are controlled from the same controller and ramp in speed together. In addition to logged data, the evaluation team performed spot power measurements throughout the speed range of the fan. The results of the spot measurements and correlations are presented in Figure 101 and Figure 102.

Figure 101: Amperage Readings to Fan Speed Correlation



Source: DNV KEMA analysis

Figure 102: Fan Speed to Spot-measured Fan Power (kW)



Source: DNV KEMA analysis

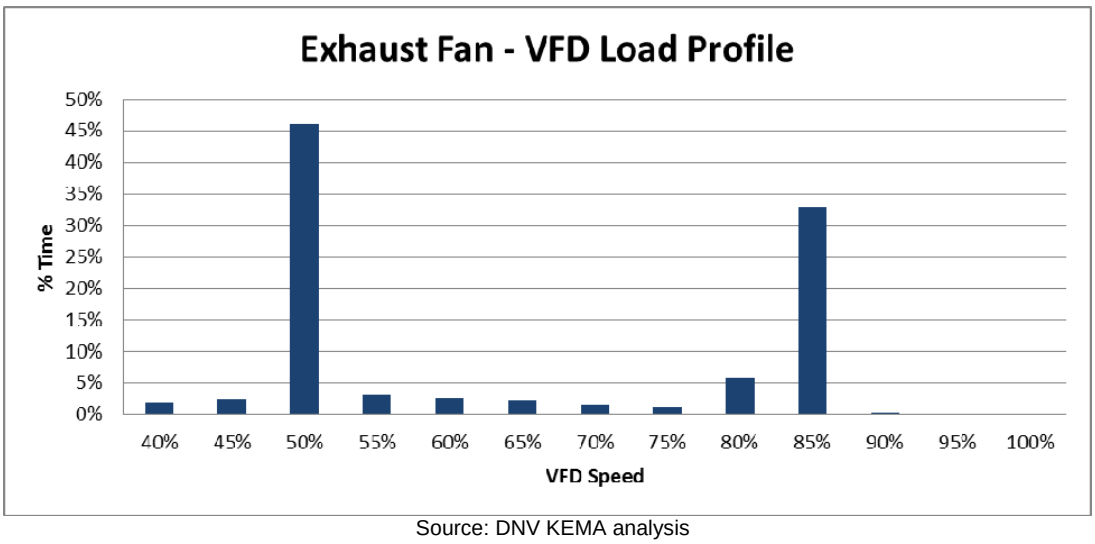
The metered data, presented in Figure 103, shows a consistent daily pattern with morning and evening periods of high use. These results are consistent with descriptions from the site contacts and the information presented in the program documentation. The VFD fans were set to a minimum speed of 30 hertz (Hz). The fans hovered around this minimum through most of the early morning off-peak hours. The logged data was used to develop the annual load profile, shown in Figure 104, which was the basis of the annual savings calculations.

Figure 103: Metered Fan Speed

Average Fan Speed								
Ave Speed (Hz) Weekday								
Hour	1	2	3	4	5	6	7	Average
0	36.8	30.0	30.0	30.0	30.0	30.0	43.5	33.1
1	36.8	30.0	30.0	30.0	30.0	30.0	43.1	33.0
2	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0
3	39.4	42.5	39.0	42.8	37.2	34.5	40.3	39.2
4	46.0	50.6	43.8	50.6	50.4	49.3	48.0	48.3
5	49.8	50.7	43.8	50.7	50.6	48.4	50.3	49.1
6	45.5	51.3	44.1	49.1	48.3	42.1	46.2	46.5
7	44.7	51.0	42.1	42.3	40.6	49.4	43.6	44.9
8	40.3	45.5	41.0	40.4	37.1	44.4	42.9	41.7
9	37.1	40.8	45.2	41.4	41.3	43.5	38.3	40.9
10	46.3	45.7	48.6	45.5	42.2	43.6	43.9	44.9
11	38.6	39.8	47.5	39.5	33.1	44.1	41.6	40.3
12	31.4	33.0	42.7	31.4	34.7	43.6	34.3	35.5
13	30.2	36.5	42.0	37.9	46.2	43.5	37.5	39.0
14	41.1	50.3	50.5	44.0	45.3	44.5	48.5	46.1
15	42.3	45.3	50.4	40.0	50.0	43.5	49.8	45.7
16	32.5	32.0	45.1	32.6	44.8	43.5	42.5	38.7
17	30.1	30.1	34.7	30.1	34.3	43.8	37.1	34.3
18	30.3	30.2	30.6	30.4	30.7	43.9	37.1	33.5
19	30.3	30.2	30.4	30.3	30.1	43.8	37.1	33.3
20	30.3	30.2	30.3	30.1	30.0	43.9	36.9	33.3
21	30.2	30.2	30.2	30.1	30.0	43.6	36.8	33.2
22	30.0	30.2	30.0	30.0	30.0	43.6	36.7	33.1
23	30.0	30.1	30.0	30.0	30.0	43.5	36.8	33.1
Average	**36.7**	**38.2**	**38.7**	**36.3**	**37.8**	**42.2**	**40.9**	**38.7**

Source: DNV KEMA analysis

Figure 104: Metered Annual Fan Load Profile



Source: DNV KEMA analysis

Annual savings were modeled using fan affinity law calculations calibrated to spot-measured data. The part-load model was calibrated using spot-measured kW and speed measurements. This calibration is shown in Figure 106. Annual hours of operation were assumed to be 5,110 hours per year in the baseline and 8,760 hours per year in the installed.

Figure 105: Annual Savings Calculations

Description	HP	Qty	Estimated Load	Efficiency	Demand kW	Total Demand kW
Kitchen Supply Fan	7.5	1	68%	80.1%	4.7	4.7
Kitchen Exhaust Fan	5	1	70%	80.1%	3.3	3.3
Total		**1**				**8.0**

Existing Fan Demand	8.0	kW

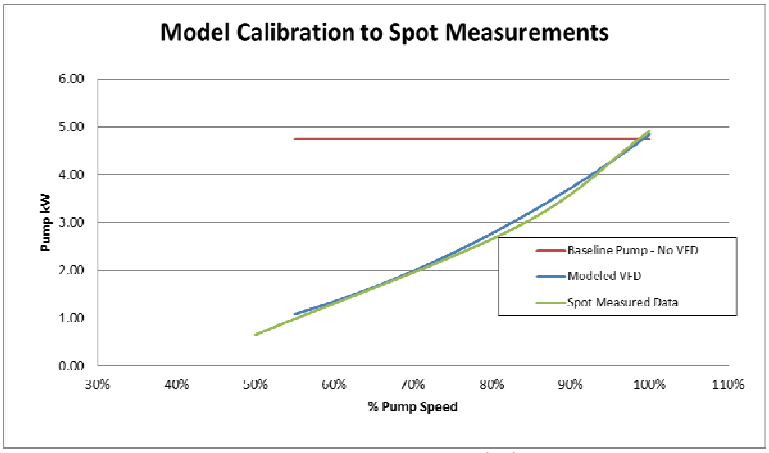
VFD Parameters	
Power-to-speed reduction exponent	2.5
Average VFD efficiency penalty	2.0%

Hours of Operation	
Baseline	5,110
Installed	8,760

Output Load Level	Metered Data %Time at Load	Baseline w/o VFD kW	Installed w/VFD kW	Baseline w/o VFD kWh	Installed w/VFD kWh	Energy Savings kWh
100%	0%	8.01	8.17	0	0	0
95%	0%	8.01	7.19	0	0	0
90%	0%	8.01	6.28	20	27	-7
85%	33%	8.01	5.44	13,454	15,677	-2,223
80%	6%	8.01	4.68	2,360	2,363	-3
75%	1%	8.01	3.98	527	449	78
70%	2%	8.01	3.35	662	474	187
65%	2%	8.01	2.78	891	531	360
60%	3%	8.01	2.28	1,042	508	534
55%	3%	8.01	1.83	1,323	519	804
50%	46%	8.01	1.44	18,858	5,831	13,026
45%	2%	8.01	1.11	979	233	747
40%	2%	8.01	0.83	813	144	669
	100%		**TOTALS**	**40,928**	**26,756**	**14,172**

Source: DNV KEMA analysis

Figure 106: Power-to-speed Reduction Exponent and Estimated Load Calibration



Source: DNV KEMA analysis

The evaluator, ERS, determined demand savings for this measure by filtering the logged data for the 2 p.m.-to-5 p.m. period on weekdays and input the demand-period load profile into the Excel model of the system detailed above in Figure 106. Interactive savings with the chiller plant were not considered in the ex ante calculations and as such were not considered in the ex post calculations.

Measure 4 – Indoor Lighting Upgrade

On-site verification activities confirmed that the lighting measure was installed as detailed in the ex ante calculations. A sample of LED exit signs as well as occupancy sensors were verified in each of the four buildings included in this measure. No changes were made to the ex ante savings figures.

Measure 5 - High Efficiency Rooftop HVAC Units

On-site verification activities determined that nine rooftop packaged HVAC units were installed as part of this measure. The nine units which were installed at the Coroner's Office and Cascade office were not of the efficiency levels stated in the ex ante calculations. The units varied between SEER of 13.2 and 13.0 as compared to an SEER of 14 as listed in the program documents.

The revised annual savings analysis was performed using the full-load hours from the original ex ante Trane Trace model and the revised count and efficiency of the RTUs. Calculations were made using the standard EFLH spreadsheet.

Savings Results

Taking into account all five EEMs, the Shasta County project resulted in 339,295 kWh in annual gross first-year energy savings and peak demand savings of 77.95 kW. Baseline 2 annual energy savings are 264,578 kWh in annual gross energy savings and 37.72 kW in peak demand savings compared to Title 24-compliant equipment. A breakdown of savings by individual measure is presented in Table 234 at the beginning of this report. The ex ante savings estimates, which were acquired from the program's monthly status reports, are also provided as a point of reference.

Discussion

Measure 1 –High Efficiency Chillers

On-site verification activities confirmed that the chillers were installed as detailed in the program documentation. Six months of chiller logs were used to determine the annual weather-dependent cooling load as well as installed chiller performance. Ex ante savings calculations assumed an installed chiller performance of 0.6 kW/ton and approximately 4,130 full-load annual hours of operation. Ex post savings models showed an average chiller performance of 0.45 kW/ton, but with only 1,540 full-load annual hours of operation. Finally, because the existing chiller was at the end of its useful life as determined by the descriptions in the program documentation as well as through conversations with site contacts, savings were compared against a Title 24-compliant centrifugal chiller for Baseline 2 savings.

Measure 2 –Parking Garage VFD Exhaust

On-site verification activities confirmed that the fan, sensors, and VFDs were installed as described in the program documentation. Three weeks of on-site metering showed that this equipment only operates 148 hours/year, slightly less than assumed in the ex ante calculations. Site contacts confirmed that the exhaust fan operated 8,760 hours/year before the installation of the VFD controls.

Measure 3 –Kitchen Hood VFD Exhaust

On-site verification confirmed that the fan, sensors, and VFDs were installed as described in the program documentation. Three weeks of on-site metering was used to develop the part-load fan curves. The metered data also showed that the new system operates 8,760 hours/year and does not completely turn off during off peak hours but ramps down to 50 percent speed. Site contacts confirmed that the exhaust hoods operated 5,110 hours/year before the installation of the VFD controls.

Measure 4 –Indoor Lighting Upgrade

On-site verification activities confirmed that the lighting measure was installed as detailed in the ex ante calculations. A sample of LED exit signs and occupancy sensors were verified in each of the four buildings included in this measure. No changes were made to the ex ante savings figures.

Measure 5 - High Efficiency Rooftop HVAC Units

The revised annual savings analysis was performed using the full-load hours from the original ex ante Trane Trace model and the revised unit counts and efficiency of RTUs determined during the site visit. Calculations were made using the standard EFLH spreadsheet.

Ex Post Life-cycle Savings

Energy savings were calculated relative to two established baselines referred to as Baseline 1 and Baseline 2. Baseline 1 considers the existing conditions found prior to the EEM implementation, and it takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have operated for the full EUL of the new equipment regardless of whether the existing equipment was at the end of its useful life. In contrast, Baseline 2 uses the pre-existing equipment as the measure baseline until the end of the existing equipment's RUL. After the remaining useful-life period and up until the end of the EUL of the installed measure, an expected replacement baseline is used. This baseline considers minimally code-compliant conditions or standard practice where no code is applicable.

Table 236 provides the EUL and RUL for each measure.

Table 236: Expected Useful Life and RUL

Measure	EUL (years)	RUL (years)
EEM1 – High efficiency chillers	20	2
EEM2 – Parking garage VFD exhaust	15	0
EEM3 – Kitchen hood VFD exhaust	15	0
EEM4 – Indoor lighting upgrade	15	0
EEM5 – High efficiency rooftop HVAC units	15	2

Source: DNV KEMA analysis

Table 237 & Table 238 provide life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure for both Baseline 1 and Baseline 2 savings.

Table 237: Baseline 1 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	339,295	77.95	1,470
2	2012	339,295	77.95	1,470
3	2013	339,295	77.95	1,470
4	2014	339,295	77.95	1,470
5	2015	339,295	77.95	1,470
6	2016	339,295	77.95	1,470
7	2017	339,295	77.95	1,470
8	2018	339,295	77.95	1,470
9	2019	339,295	77.95	1,470
10	2020	339,295	77.95	1,470
11	2021	339,295	77.95	1,470
12	2022	339,295	77.95	1,470
13	2023	339,295	77.95	1,470
14	2024	339,295	77.95	1,470
15	2025	339,295	77.95	1,470
16	2026	187,707	61.35	0.0
17	2027	187,707	61.35	0.0
18	2028	187,707	61.35	0.0
19	2029	187,707	61.35	0.0

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
20	2030	187,707	61.35	0.0
Total		6,027,960 kWh		22,050 Therms

Source: DNV KEMA analysis

Table 238: Baseline 2 Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electrical Demand (kW)	Natural Gas Energy Savings (Therms/yr)
1	2011	339,295	77.95	1,470
2	2012	339,295	77.95	1,470
3	2013	264,578	47.62	1,470
4	2014	264,578	47.62	1,470
5	2015	264,578	47.62	1,470
6	2016	264,578	47.62	1,470
7	2017	264,578	47.62	1,470
8	2018	264,578	47.62	1,470
9	2019	264,578	47.62	1,470
10	2020	264,578	47.62	1,470
11	2021	264,578	47.62	1,470
12	2022	264,578	47.62	1,470
13	2023	264,578	47.62	1,470
14	2024	264,578	47.62	1,470
15	2025	264,578	47.62	1,470
16	2026	121,699	37.72	0.0
17	2027	121,699	37.72	0.0
18	2028	121,699	37.72	0.0
19	2029	121,699	37.72	0.0
20	2030	121,699	37.72	0.0
Total		4,726,599 kWh		22,050 Therms

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

North Coast Integrated Regional Water Management Plan (Humboldt County), Crescent City Water Pumping Motor Replacement and VFD Addition(CBG-09-199-D)

Site Summary

The County of Humboldt implemented energy efficiency improvements to a three pump facility in Crescent City under the CBG-09-199 block grant. This project replaced two existing 125 hp pump motors with NEMA Premium efficiency motors and added VFDs to all three pump motors. These pumps are used to pump water to an elevated storage tank. A summary of the energy savings is presented in Table 239.

Table 239: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
New motor and VFD	214,533	35.1	N/A	214,553	35.1	N/A	100%	N/A
Total	214,553	35.1	N/A	214,553	35.1	N/A	100%	N/A

Source: DNV KEMA analysis

The ex ante savings calculation included a detailed analysis indicating 214,553 kWh. The ex post analysis revealed that the ex ante analysis credibly represents the operational performance of the pumps, VFDs, and motors. On-site evaluation activities confirmed that the operating schedule of the pumping facility matched the trend data used in the calculation and that the VFDs are operating at reduced speed as predicted. Therefore, the ex post savings equal the ex ante savings, resulting in a realization rate of 100 percent.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on a single baseline that uses the pre-existing condition as the baseline for the full EUL of the installed measure. For the new motors, DEER provides an EUL of 15 years.

Table 240: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline1	4,082,010	35.1	N/A

Source: DNV KEMA analysis

Project Description

This project replaced the motors of two of the three pumps at a facility that pumps water to an elevated storage tank. The third pump had previously been replaced and was not part of the scope of this project. VFDs were also installed on each of the three pumps.

Project Evaluation

The evaluation team visited the city on May 21, 2012, to verify the installation of the motors and VFDs. The team also observed the running conditions of the motor and interviewed site staff.

Figure 107 shows the nameplate of one of the new motors. Figure 108 shows the date the new motors were installed. Figure 109 shows the running conditions at the VFD display.

Figure 107: Nameplate of the New Motor

Photo Credit: DNV KEMA

Figure 108: New Motor Installation Date

Photo Credit: DNV KEMA

Figure 109: VFD Display

Phtoto Credit: DNV KEMA

Savings Results

The ex post savings calculation resulted in 214,553 kWh in annual energy savings. Demand savings of 35.1 kW were also realized.

Discussion

A detailed analysis of the ex ante energy savings was provided. The ex post analysis revealed that the ex ante analysis credibly represents the claimed energy savings of this project. The calculation used pump run-time data provided by the city that showed one pump runs almost continuously, a second pump runs for four to five hours per day during the peak season, which is about 8 weeks in the summer, and the third pump is a back-up.

During the site visit, the amperage, voltage, and power factor of the operating pump were measured. Using these, a demand of approximately 75 kW, or 100 hp, was calculated, demonstrating that the motor is operating at a reduced speed.

Ex Post Life-cycle Savings

Energy savings were calculated relative to a single baseline (Baseline 1). The baseline the evaluation team has determined is appropriate considers the existing conditions found prior to the EEM implementation. It takes into account the equipment's operating efficiency along with the control strategies found at that time.

Table 241 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 241: Life-cycle Savings

Life-cycle	Year	Electric Energy Savings (kWh/yr)	Demand Reduction (kW)	Therm Savings
1	2012	272,134	35.1	N/A
2	2013	272,134	35.1	N/A
3	2014	272,134	35.1	N/A
4	2015	272,134	35.1	N/A
5	2016	272,134	35.1	N/A
6	2017	272,134	35.1	N/A
7	2018	272,134	35.1	N/A
8	2019	272,134	35.1	N/A
9	2020	272,134	35.1	N/A
10	2021	272,134	35.1	N/A
11	2022	272,134	35.1	N/A
12	2023	272,134	35.1	N/A
13	2024	272,134	35.1	N/A
14	2025	272,134	35.1	N/A
15	2026	272,134	35.1	N/A
Total		4,082,010	526.5	N/A

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

Humboldt County, City of Eureka Retrofits (CBG-09-199-F)

Site Summary

This project involved the retrofit of various types of lighting fixtures throughout seven facilities located in the City of Eureka. The project also included an HVAC control and VFD retrofit at City Hall and the replacement of an existing DHW boiler at the Adorni Recreation Center. The measures evaluated were those listed in the information provided by the Energy Commission on April 17, 2012.

Table 242 summarizes the ex ante and ex post savings estimates for this project.

Table 242: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Peak Demand (kW)	Gas Energy (Therms)	Electric	Gas
EEM1 - DHW boiler replacement	N/A	N/A	296	N/A	N/A	219	0%	73.8%
EEM2 - HVAC retrofit	6,398	NA	1,119	0	0	0	0%	0%
EEM3 - Lighting retrofit	74,663	32.8	N/A	74,663	33	N/A	100%	N/A
Total	81,061	32.8	1,415	74,663	33	219	92.1%	15.4%

Source: DNV KEMA analysis

The boiler measure, originally planned for multiple units, was reduced to the single hot water system replacement evaluated in this report.

The HVAC retrofit, in its operational status at the time of the evaluation, was not achieving any energy savings. The installation of DDC controls was intended to bring about energy savings by optimizing the control of the two separate heating systems; however, it was discovered that the controls are not integrated and, thus, they are not able to optimize system operation. In addition, the installed VFDs were to allow the supply air system fans to operate at lower speeds during mild weather. However, it was discovered that the heating supply air system is undersized and the VFDs must constantly run at full speed; thus, no energy savings were being achieved at the time of the evaluation. Later reports provided to the Energy Commission suggest that subsequent commissioning and tuning likely have resulted in savings.

The lighting measures were found to be installed and operating as reported, resulting in no differences between ex ante and ex post energy savings.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For the lighting and HVAC retrofit, the baselines are identical. For the DHW boiler measure, Baseline 1 is based on the efficiency of the replaced boiler and Baseline 2 is based on minimum efficiency standards for gas-fired boilers (Title 24- 2008 BEES).

An EUL of 15 years is used for all measures.

Table 243: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Peak Demand Reduction (kW)	Natural Gas Energy Savings (Therms)
Baseline 1	1,119,945	33	3,285
Baseline 2	1,119,945	33	2,613

Source: DNV KEMA analysis

Project Description

This project involved the retrofit of various types of lighting fixtures throughout seven facilities (city garage, Adorni Center, fire departments 3&4, main fire department, municipal auditorium, and police annex) located in the city of Eureka. The project also included an HVAC control and VFD retrofit at Eureka City Hall and the replacement of an existing DHW boiler at the Adorni Recreation Center.

The lighting retrofit consists of more than 400 measures, including T12 to HPT8 lamp and ballast retrofits; MH to HPT8; 8 ft.,T12 HO lamp to T8 lamp; CFLs, occupancy sensors, and exit signs.

The HVAC project consisted of a controls upgrade and the installation of six VFDs on supply air fan motors. City Hall has two heating systems and no cooling system. The first heating system is a perimeter hot water radiator system and the second heating system consists of air handlers with hot water coils. They are controlled by an existing pneumatic control system. A hot water boiler provides heating for the air handler system and two hot water boilers provide heat for the radiator system. The air handlers provide fresh air through fixed outside air dampers.

The Adorni Recreation Center is served by four DHW boilers. Although original plans called for replacing all boilers, the final project scope consisted of replacement of one boiler.

Project Evaluation

The evaluation team visited the facility on May 15, 2012, to verify the installation and operation of the lighting, DHW, and HVAC measures.

Measure 1 – DHW Boiler Replacement

Site staff indicated that only one of the boilers was replaced. To estimate energy savings, the installed boiler's efficiency was used and the ex ante calculation methodology was then updated to account for only one boiler being installed. The ex ante savings assume a hot water demand of 52 gallons per hour for the entire facility. The evaluators used 25 percent of this demand for estimating the energy savings from one boiler replacement.

Measure 2 – HVAC Retrofit

The project feasibility study indicated energy savings would be achieved through the installation of a new DDC control system and the installation of VFDs on the supply air fans. A bin analysis was described in the feasibility study, but the analysis itself was not provided. Savings would be achieved through optimal control and sequencing of both heating systems and by operating supply air fans at minimum outside airflow conditions during mild weather.

Site staff led the evaluation team during an inspection of the existing system and its operation. The staff indicated that the existing system is undersized and for that reason the supply air must remain constant. The VFDs were observed to be operating at full speed, and the staff confirmed that the fan speed is never modulated. The staff also indicated that the control system was never completely integrated and that any control sequencing strategies proposed were not being used.

Given that the energy savings strategies that were responsible for achieving energy savings were not effectively deployed and the bin analysis model used to estimate savings was not provided, no energy savings could be verified.

Measure 3 – Lighting Retrofit

The evaluation team surveyed each facility and inspected the majority of lighting fixtures retrofitted. Site staff confirmed each facility's operating hours. No discrepancies were found between the inspected lighting fixtures and those reported in the project's ex ante savings documentation.

Savings Results

The total annual energy savings for all projects was verified as 74,633 kWh and 219 therms. A non-coincident demand reduction of 33 kW was also realized.

Ex Post Life-cycle Savings

Energy savings were calculated relative to dual baselines. Baselines 1 and 2 are identical for the lighting measure. For the DHW boiler replacement, Baseline 1 is based on the ex ante savings analysis listed efficiency of 75 percent for the existing boiler. Baseline 2 is based on the

minimum equipment code efficiency mandated by Title 24-2008 BEES. The life-cycle analysis is based on an EUL of 15 years.

Table 244: Life-cycle Savings

		Baseline 1		Baseline 1	Baseline 2
Life-cycle	Year	Electric Energy Savings (kWh/yr)	Electric Demand (kW)	Natural Gas Energy Savings (Therms/yr)	Natural Gas Energy Savings (Therms/yr)
1	2012	74,663	33	219	219
2	2013	74,663	33	219	171
3	2014	74,663	33	219	171
4	2015	74,663	33	219	171
5	2016	74,663	33	219	171
6	2017	74,663	33	219	171
7	2018	74,663	33	219	171
8	2019	74,663	33	219	171
9	2020	74,663	33	219	171
10	2021	74,663	33	219	171
11	2022	74,663	33	219	171
12	2023	74,663	33	219	171
13	2024	74,663	33	219	171
14	2025	74,663	33	219	171
15	2026	74,663	33	219	171
Total		1,119,945		3,285	2,613

Source: DNV KEMA analysis

ON-SITE EVALUATION REPORT
EECBG

County of Humboldt, Rio Dell HVAC Replacement (CBG-09-199-M)

Site Summary

This project involved replacing three furnaces and four split-system air-conditioningair-conditioning units at Rio Dell City Hall. Table 245 summarizes the electric and gas savings of this project.

Table 245: Energy Savings Summary

Measure	Ex Ante			Ex Post			Realization Rate	
	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric Energy (kWh)	Demand (kW)	Gas Energy (Therms)	Electric	Gas
HVAC replacement	935	N/A	403	375	5.0	420	40%	104%
Total	935	N/A	403	375	5.0	420	40%	104%

Source: DNV KEMA analysis

The difference between the ex ante and ex post electric savings is primarily due to differences in calculated operating hours during the cooling season. The ex ante analysis (from the project feasibility report) assumes more than 200 equivalent full-load operating hours (EFLH) for cooling. However, the evaluation team estimated 75 EFLH, based on TMY3 weather data measured at the nearby Arcata airport.

The ex ante natural gas savings was confirmed by the ex post analysis, with only a slight difference.

In addition to first-year savings, project life-cycle savings were also assessed as part of the evaluation. Life-cycle savings were analyzed based on two baselines:

- Baseline 1, which uses the pre-existing condition as the baseline for the full EUL of the installed measures
- Baseline 2, the dual baseline, which uses minimally code-compliant conditions or standard practice as the baseline once the RUL of the pre-existing equipment has been exceeded

For HVAC retrofits, DEER provides an EUL of 15 years.

Table 246: Life-cycle Savings Summary

Baseline Type	Electrical Energy Savings (kWh)	Demand Reduction (kW-years)	Natural Gas Energy Savings (Therms)
Baseline 1	5,625	75.0	6,300
Baseline 2	949	66	6,300

Source: DNV KEMA analysis

Project Description

This project replaced three furnaces with high-efficiency furnaces in the city hall. Four split-system air-conditioning units were also replaced.

Project Evaluation

The evaluation team visited the city on May, 21, 2012, to verify the installation of the furnaces and air-conditioning units. The site staff members were interviewed to determine the hours of operation at Rio Dell City Hall.

Figure 110 shows the nameplate of one of the air-conditioning units installed at City Hall.

Figure 110: City Hall Air-conditioning Unit Nameplate

Photo Credit: DNV KEMA

Savings Results

The ex post savings calculation resulted in 375 kWh in annual energy savings. Demand savings of 5.0 kW were also realized.

Discussion

On-site verification activities confirmed that the three furnaces and four air-conditioning units had been installed. An interview with the site contact verified the operating hours of the

building, which are 8 a.m. to 5 p.m., Monday through Friday. The contact was unable to verify the age of the baseline equipment, but thought that it was at least 20 years old. The weather bin analysis used TMY3 data taken from the National Renewable Energy Laboratory (NREL) for the Arcata-Eureka Airport in the nearby town of Arcata. No operational deficiencies were reported regarding the baseline equipment. A degradation factor of 10 percent was assumed due to the age of the equipment.

The heating weather bin analysis included operation deficiency factors that were described in the project's feasibility report. The report estimated a 20 percent degradation factor to account for the supply air duct leakage, which was fixed as part of the retrofit. This factor was included in the ex post analysis. the report also indicates that the original furnaces were oversized, leading to operational inefficiencies, although no factor was provided. For the bin analysis, a 2 percent efficiency degradation factor was also used in addition to the 20 percent degradation to account for right-sizing the furnaces.

Ex Post Life-cycle Savings

Energy savings were calculated relative to both Baseline 1 and Baseline 2. For HVAC, Baseline 1 is based on the replaced equipment's estimated efficiency and Baseline 2 is based on minimum code requirements at the time of the replacement. For natural gas savings, the stated efficiency for the replaced furnaces was higher than code requirements; therefore, the efficiency of the replaced units is used in the analysis.

Table 247 provides life-cycle savings for the project on a year-by-year basis through the EUL of the longest-lived measure.

Table 247: Life-cycle Savings

		Baseline 1			Baseline 2		
Life-cycle	Year	Electric Energy Savings (kWh/yr)	Demand Reduction (kW)	Therms Savings	Electric Energy Savings (kWh/yr)	Demand Reduction (kW)	Therms Savings
1	2012	375	5.0	420	375	4.4	420
2	2013	375	5.0	420	41	4.4	420
3	2014	375	5.0	420	41	4.4	420
4	2015	375	5.0	420	41	4.4	420
5	2016	375	5.0	420	41	4.4	420

		Baseline 1			Baseline 2		
Life-cycle	Year	Electric Energy Savings (kWh/yr)	Demand Reduction (kW)	Therms Savings	Electric Energy Savings (kWh/yr)	Demand Reduction (kW)	Therms Savings
6	2017	375	5.0	420	41	4.4	420
7	2018	375	5.0	420	41	4.4	420
8	2019	375	5.0	420	41	4.4	420
9	2020	375	5.0	420	41	4.4	420
10	2021	375	5.0	420	41	4.4	420
11	2022	375	5.0	420	41	4.4	420
12	2023	375	5.0	420	41	4.4	420
13	2024	375	5.0	420	41	4.4	420
14	2025	375	5.0	420	41	4.4	420
15	2026	375	5.0	420	41	4.4	420
Total		5,625	75	6,300	949	66	6,300

Source: DNV KEMA analysis

Glossary for On-site Evaluation Reports

Baseline 1	Considers the existing conditions found prior to the energy efficiency measures (EEM) implementation and takes into account the equipment's operating efficiency along with the control strategies found at that time. Life-cycle savings for Baseline 1 assumes the pre-existing equipment would have continued to operate indefinitely, up to the effective useful life (EUL) of the new equipment.
Baseline 2	Uses the pre-existing equipment as the measure's baseline until the end of the existing equipment's remaining useful life (RUL). After the remaining useful-life period, and up until the end of the EUL of the installed measure, the measure's expected-replacement baseline is used. This baseline considers either minimally code-compliant conditions or standard practice when no code is applicable.
BFW	Baseline fixture wattage (kW)
CDP	census designated place
CFL	compact florescent lamp
COP	coefficient of performance
CT	current transducer
DEER	The California Database for Energy Efficient Resources
DHW	domestic hot water
DOE	Department of Energy
EEM	energy efficiency measure or measures
EFLH	effective full load hour
Energy Commission	California Energy Commission
EPRI	Electric Power Resource Institute
EUL	estimated useful life
ex ante	energy savings estimates for an energy efficiency measure developed by the site or the program implementers
ex post	energy savings estimates for an energy efficiency measure developed by the site or the program implementers
HID	high intensity discharge
hp	horsepower
HPS	high-pressure sodium
HSPF	Heating Seasonal Performance Factor
HVAC	heating, ventilation, and air-conditioning
Hz	hertz
kBtu	kilo British thermal unit
kW	kilowatt
kWh	kilowatt-hour

LADWP	Los Angeles Department of Water and Power
LED	light-emitting diode
life-cycle savings	savings accrued for the effective useful life (EUL) of the measure, equal to the EUL multiplied by the annual savings
M&V	Measurement and Verification
measure	at an end-use energy consumer facility, an installed piece of equipment or system; a strategy intended to affect consumer energy use behaviors; or modification of equipment, systems, or operations that reduces the amount of energy that would otherwise have been used to deliver an equivalent or improved level of end-use service.[43]
MH	metal halide
MV	mercury vapor
NEEP	Northeast Energy Efficiency Partnerships
NEMA	National Electrical Manufacturers Association
NREL	National Renewable Energy Laboratory
PG&E	Pacific Gas and Electric Company
PostRunHrs	Post-retrofit annual hours of operation for usage group (assumed to be the same except for one group, which involved the installation of occupancy sensors)
project	an activity or course of action involving one or multiple energy efficiency measures, at a single facility or site.
PW	Public Works
RFQ	Retrofit fixture quantity (#)
RFW	Retrofit fixture wattage (kW)
RTU	rooftop unit
RUL	remaining useful life
SCE	Southern California Edison
SEER	Seasonal Energy Efficiency Ratio
THI	temperature-humidity index
TMY	typical meteorological year
U.S. DOE	United States Department of Energy
VFD	variable frequency drive
WWTP	wastewater treatment plant

43 Definition for measure and project from the Energy Efficiency Program Impact Evaluation Guide, December 2012, published by the State & Local Energy Efficiency Action Network.